TM 11-2005

WAR DEPARTMENT TECHNICAL MANUAL

REPEATER SET TC-19

(INTERMEDIATE, TELEGRAPH)

WAR DEPARTMENT • JANUARY 1947

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BY ORDER OF THE SECRETARY OF WAR:

OFFICIAL:
EDWARD F. WITSELL
Major General
The Adjutant General

DWIGHT D. EISENHOWER
Chief of Staff

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WARNING

If necessary to remove the repeater from the carrying case, disconnect power cord from the power source. Avoid touching terminals with bare hands while testing. All test leads should be insulated.

DESTRUCTION NOTICE

WHY—To prevent the enemy from using or salvaging this equipment for his benefit.

WHEN—When ordered by your commander.

HOW—1. Smash—Use sledges, axes, handaxes, pickaxes, hammers, crowbars, heavy tools.
2. Cut—Use axes, handaxes, machetes.
3. Burn—Use gasoline, kerosene, oil, flame throwers, incendiary grenades.
4. Explosives—Use firearms, grenades, TNT.
5. Disposal—Bury in slit trenches, fox holes, other holes. Throw in streams. Scatter.

USE ANYTHING IMMEDIATELY AVAILABLE FOR DESTRUCTION OF THIS EQUIPMENT

WHAT—1. Smash—Carrying case cover, panels, telegraph key, meter, switches, jacks, relays, resistors, capacitors, headset, and framework.
2. Cut—Transformer coil windings, relay windings, all wiring and cables.
3. Burn—Carrying case, manuals in canvas pocket.
4. Bend—Frameworks and panels.
5. Bury or scatter—Any or all of the above pieces after destroying their usefulness.

DESTROY EVERYTHING

PART ONE

INTRODUCTION

Section I. DESCRIPTION OF REPEATER SET TC-19 (INTERMEDIATE, TELEGRAPH)

1. General

a. Repeater Set TC-19 (Intermediate, Telegraph) is a portable direct-current (d-c) telegraph repeater set consisting of two Ground Rods MX-148/G and one Repeater TG-31 (Intermediate, Telegraph). Repeater TG-31 (Intermediate, Telegraph) is a d-c telegraph repeater designed for use as an intermediate repeater located between terminal repeaters. Repeater TG-31 is designed to repeat the telegraph signals in either direction, but not in both directions at the same time. The distant terminal repeater equipment should be Repeater TG-30 (Terminal, Telegraph), or its equivalent. Only one Repeater TG-31 can be used in the line circuit between two terminal repeaters, or between a terminal repeater and a carrier telegraph terminal. Repeater TG-31 is designed for unattended operation so far as service adjustments are concerned.

b. Repeater TG-31 can be used on field-wire line circuits (simplexed), spiral-four cable circuits (simplexed), or open-wire circuits (composited or simplexed) with ground return.

c. The local side of the repeater is arranged for connecting a teletypewriter for sending and receiving. A manual telegraph set integral with the repeater equipment can be used when a teletypewriter is not available.

d. A source of 115-volt or 230-volt, 50- to 60-cycle alternating current (ac), 115-volt direct current (dc) (gasoline-engine power unit or dry batteries), or a 12-volt storage battery is required to operate the equipment.

2. Table of Components for Repeater Set TC-19

The items listed below are the components of Repeater Set TC-19 (Intermediate, Telegraph). Refer to appendix I and to the Signal Corps catalog for a complete list of component parts for Repeater TG-31. The data given below are for the equipment unpacked and ready for use.

Quantity	Component	Weight (lb)	Dimensions (in.)	Volume (cu ft)
1....	Repeater TG–31 (Intermediate, Telegraph).	120....	25 x 16 x 14½	3.5
2....	Ground Rod MX–148/G.	9.5 (ea)	72 x ¾ (diam)	.....

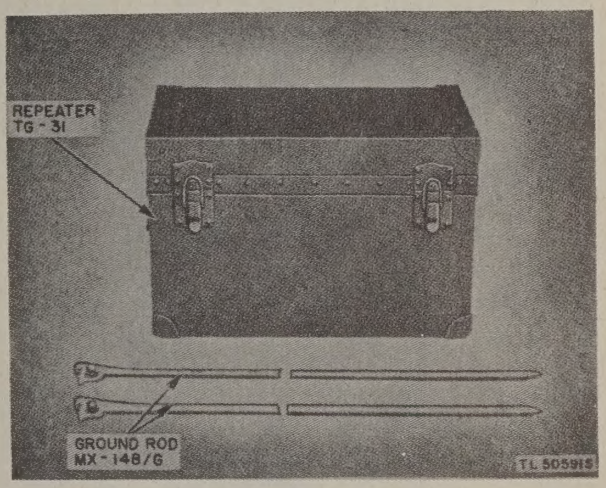


Figure 1. Components of Repeater Set TC-19 (Intermediate, Telegraph).

3. Description of Repeater TG-31 (Intermediate, Telegraph)

a. The repeater is housed in a durable wooden carrying case (fig. 2) which completely incloses all equipment while in transit. A carrying handle is provided on each end of the case. The major component parts are a repeater unit and a rectifier power-supply unit. The apparatus comprising these units is assembled on mounting plates so arranged that the complete assembly may be removed and located on 19-inch relay racks. While in the carrying case, the basic framework is supported on shock-absorbing mountings. The equipment is constructed

for use over a wide temperature range and for use under tropical conditions. Filters to suppress induction from power lines are not furnished.

b. The repeater with the carrying case open for service is shown in figure 3. Binding posts for making connections, switches, keys, fuses (with spares), a potentiometer, a meter used for measuring d-c repeater voltage, and the manual telegraph key used for manual telegraph operation are conveniently assembled and clearly designated on the face of the equipment (fig. 4). The repeater equipment is also furnished with a receptacle and jacks for connecting a teletypewriter (power and transmission cords), a jack for connecting the headset used with manual telegraph operation, and a jack which can be used to supply power to a relay test set such as Test Set I-193-A. During periods of unattended service, the cover of the carrying case

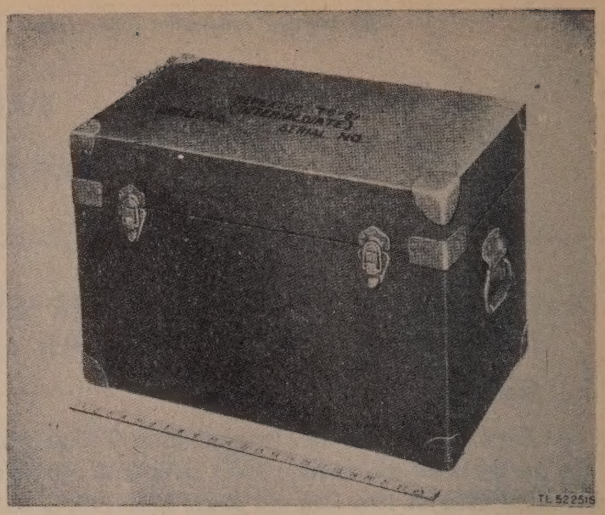


Figure 2. Repeater TG-31 (Intermediate, Telegraph), ready for transit.

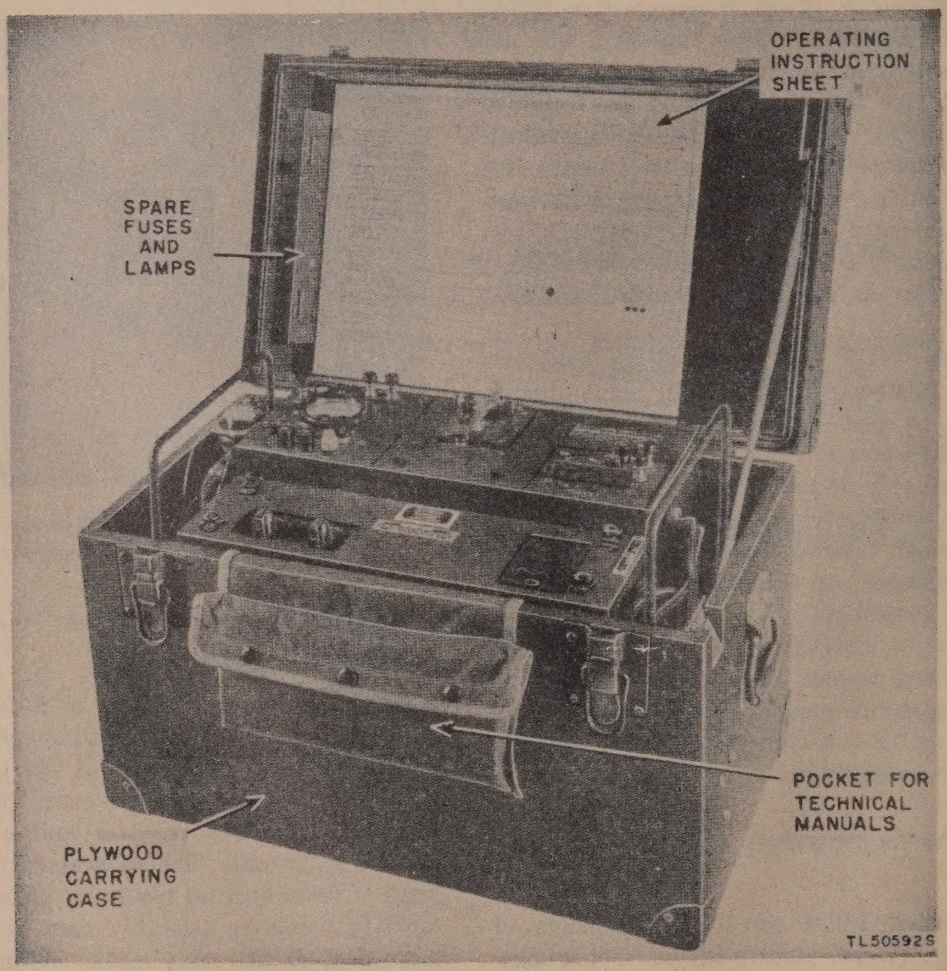


Figure 3. Repeater TG-31 (Intermediate, Telegraph), carrying case open for service.

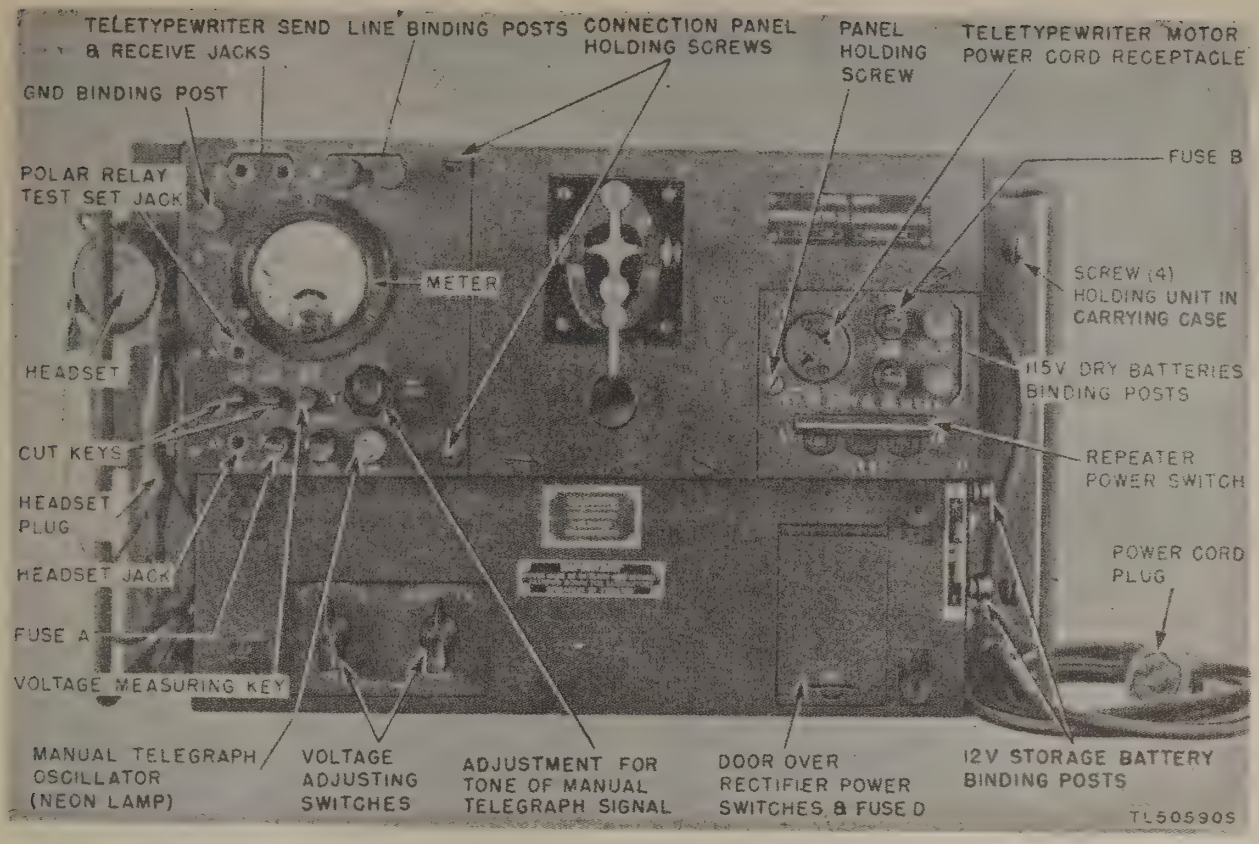


Figure 4. Repeater TG-31 (Intermediate, Telegraph), removed from carrying case, top view.

is closed and the leads are carried through a waterproof joint between the carrying case and its cover.

c. Storage space is located inside the cover of the carrying case for spare fuses, and spare neon lamps (used in the manual telegraph circuit). Line protectors and spares are located inside the repeater unit. The headset and connected cord and plug, used for manual telegraph operation, are held in place by clamps on the side of the unit when not in use.

d. A summary of operating instructions, which is condensed from the instructions given in this manual, is attached inside the cover of the carrying case. Circuit-label diagrams (figs. 33 and 34) are mounted in the bottom of the repeater carrying case. Technical manuals are contained in a canvas pocket which is attached to the carrying case. The canvas pocket is folded over the repeater unit when the cover is closed, and hangs over the front of the carrying case when the repeater cover is open and being prepared for operation.

Note. On earlier models the canvas pocket for the technical manuals was located on the inside of the cover of the carrying case.

4. Description of Ground Rod MX-148/G

The ground rod is a galvanized steel rod, 6 feet in length and ¾ inch in diameter. It has a shaped head to facilitate driving and to protect the wingnut wire connecting device during transportation and driving.

Note. On earlier shipments of Repeater Set TC-19, Ground Rod GP-29 was shipped instead of Ground Rod MX-148/G.

5. General Functioning of Repeater TG-31

a. Line Binding Posts. Two line binding posts are provided, LINE A and LINE B. They provide for connecting the lines from terminal A and terminal B. A GND binding post is used to complete the line circuit through ground. (See fig. 4.)

b. Printer Jacks. PRINTER jacks (RED R and BLK S) are provided for making connections to the transmission cords of Teletypewriter TG-7-B, Printer TG-7-A, Teletypewriter TG-37-B, Reperforator Transmitter TG-26-A, or Reperforator Transmitter TG-27-A for local operation.

c. Power Supply. The repeater can be operated on alternating current or direct current from several

different sources (par. 7). The various controls, switches, and binding posts for the power supply are described below.

(1) *Repeater-unit power switch.* The repeater-unit power switch is used to arrange the repeater for operation on alternating current, 12-volt storage battery, or direct current. In the 115V OR 230V AC OR 12V DC position the repeater is arranged for operation on alternating current or a 12-volt storage battery. Operation on these power supplies uses the built-in rectifier. With the switch in the 115V DC position the built-in rectifier is not used and the repeater is arranged for operation directly on the d-c supply.

(2) *115/230V AC-12V STORAGE BAT switch.* This switch is used to arrange the rectifier power unit for operation on alternating current or on a 12-volt storage battery depending upon which is being used as the main power supply.

(3) *115V AC-230V AC switch.* This switch is used to arrange the repeater for operation on 115 volts or 230 volts alternating current.

(4) *DRY BAT 115V binding posts.* When 115-volt dry battery is used to supply the power, the + and — terminals are connected to the binding posts designated DRY BAT 115V.

(5) *12V STORAGE BAT binding posts.* When a 12-volt storage battery is used to supply the power, the + and — terminals are connected to the binding posts designated 12V STORAGE BAT.

(6) *Vibrator.* The vibrator provides a pulsating voltage to the transformer windings of the rectifier unit when operation is on a 12-volt storage battery. This enables the 12 volts direct current to be stepped up to the 115 volts alternating current required by the transformer windings. It is arranged for mounting in a vacuum-tube socket.

(7) *MEAS VOLTS key.* The MEAS VOLTS key is arranged to connect the meter to read the voltage of the power supply. When the main power supply is alternating current or a 12-volt storage battery, the meter indicates the output of the repeater rectifier. When the main power supply is direct current, the voltage of the external power supply is indicated.

(8) *ADJUST VOLTS switches.* The ADJUST VOLTS switches are used to obtain the required rectifier unit d-c output voltage when the main power supply is alternating current or a 12-volt storage battery. The ADJUST VOLTS switch designated COARSE is used to obtain the approximate value of voltage and the ADJUST VOLTS switch designated FINE is used to adjust the voltage to the required value.

(9) *PRINTER POWER receptacle.* The PRINTER POWER receptacle is furnished so that the power cord from the teletypewriter may be plugged in and power furnished to the teletypewriter motor. The teletypewriter can be supplied power only if the main power source is alternating current or 115-volt direct current supplied by a suitable gasoline-engine power unit or commercial source.

d. Cut Line Keys. The CUT LINE keys provide a means for terminating either of the adjacent line sections. It may be desired to terminate a line section under the following conditions:

(1) *Testing.* To cut off one line section when testing the line from Repeater TG-31 to the other terminal.

(2) *Communication.* To cut off one terminal while communicating with the other terminal.

(3) *Interference.* To block interference from a defective line section. When there is trouble in one line section, and a teletypewriter at the Repeater TG-31 station makes possible the transmission of messages to the terminal to which line facilities are good, operation of the CUT LINE key will cut off the defective line section, thus preventing bad line conditions in one line section from interfering with transmission in the other line section.

e. Manual Telegraph Set. A manual telegraph set is built in to permit a means of communication when teletypewriter equipment is not available or cannot be operated. The component parts of this set consist of a small neon lamp (TONE) connected in an oscillator circuit, a telegraph key, and a headset. A HEADSET jack provides a means of connecting the headset to the repeater. The frequency of the oscillator, that is, the tone heard in the receiver, may be regulated to suit the personnel using it by means of the adjusting knob (ADJ TONE) on the operating panel. A tone in the order of 1,000 cycles should generally be satisfactory. The manual telegraph set is inoperative when a teletypewriter is connected or when the headset is not connected.

f. Test Set Jack. The TEST SET jack is arranged so that d-c power may be furnished to Test Set I-193-A.

6. Electrical Characteristics of Repeater TG-31 (Intermediate, Telegraph)

a. General. Repeater TG-31 is an intermediate

d-c telegraph repeater. It receives d-c signals over the line from the terminal equipment on one end of the system and repeats these d-c signals to the line connected to the terminal equipment on the other end of the system. Operation over the lines is on a polarential basis. The repeater may be used on teletypewriter circuits operating up to 66 words per minute (404 operations per minute (opm)).

b. Line Operation. The repeater provides for half-duplex operation only. The line sides of the repeater are arranged to use the type B polarential (differential-sending) form of transmission.

c. Cutting Feature. The cutting feature permits communication with one terminal in case the line facility to the other terminal is open or otherwise in trouble. Two cut keys, one associated with each line section, are used. When a cut key is operated, the armature of the associated relay is disabled. Through transmission is prevented when either cut key is operated.

Figure 5. Polar relay, cover in place.

d. Line Protection. Carbon block line protectors are incorporated to prevent damage to the equipment in case of line voltage surges. These blocks have an air gap of about 0.005 inch. One pair of protector blocks is connected to each line binding post of the repeater. Two pairs of spare protectors are supplied.

e. Noise Influence on Telephone Circuits. Repeater TG-31 is supplied with a retardation coil in series with each line. This serves as a noise killer to prevent undesirable noises on simplexed telephone circuits. An additional noise filter is required on composited circuits to maintain the same noise level as on simplexed circuits. This additional line filter should be provided with the composite equipment.

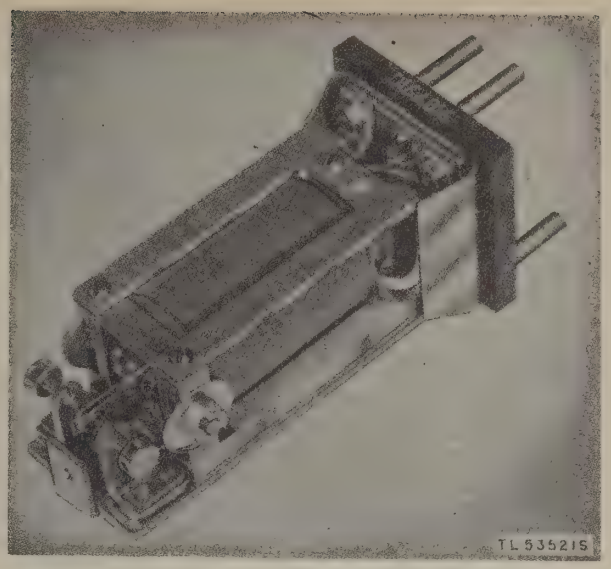


Figure 6. Polar relay, cover removed and gas adsorber units removed.

f. Radio Induction Suppression. The wiring to the line terminals, the send and receive PRINTER jacks, and the telegraph key is carried through lead-in filters, and the power cord and the PRINTER POWER receptacle is supplied with power-lead filters to reduce interference to nearby radio receiving equipment. These filters contain low-resistance air-core coils and small bypass capacitors. The filters are effective in a range from about 200 kilocycles to 18,000 kilocycles.

g. Telegraph Polar Relays. (1) The repeater uses four polar relays of the same type (figs. 5 and 6). These are the two line relays and the

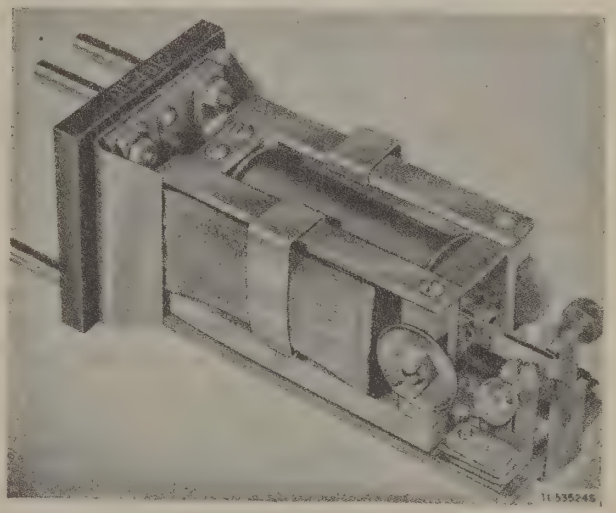


Figure 7. Polar relay, cover removed, gas adsorber units in place.

sending and receiving monitoring relays. The relay is a three-winding relay arranged for mounting in a vacuum-tube socket which serves as a connecting block. One winding is a 90-ohm winding and the other two are 1,450-ohm windings. Figure 24 shows the winding and terminal arrangements of the relay. The relay is tested and adjusted in Test Set I-193-A. One spare relay is mounted in the compartment with those in use.

(2) Each polar relay should contain two gas adsorber units (fig. 7). The adsorber units are small metal wire-cloth bags, each containing 2 grams of activated charcoal. The gas adsorber units prevent excessive contact corrosion by adsorbing any hydrocarbon vapors which may be present within the relay case. These vapors emanate from various materials such as moistureproofing and fungiproofing lacquer, paints, and phenolics used in component parts of the equipment.

7. Power

a. General. The repeater circuits require 115-volt direct current. This direct current is usually obtained from the built-in rectifier power-supply unit, which converts alternating current to direct current or steps up a 12-volt storage battery supply to 115-volt direct current. Direct current for operating the repeater circuit may also be obtained from a 115-volt d-c source such as a gasoline-engine power unit or 115-volt dry batteries. The repeater may be operated on 95 to 125 volts or 190 to 250 volts, 50- to 60-cycle alternating current, 115-volt direct current (gasoline-engine Power Unit PE-77-D, or equivalent), 115-volt direct current (three Batteries BA-26, or equivalent, connected in series (par. 19*b*(2)), or a 12-volt storage battery (two Batteries BB-55, or equivalent, connected in series). A power cord 10 feet long is provided for connection to an a-c supply or a gasoline-engine power unit. The voltage of a direct-current source (gasoline-engine power unit or dry batteries) must be regulated externally to the repeater.

b. Power Requirements. The rated output of the rectifier at 115-volt direct current is 200 milliamperes when operating from an a-c source. Rated output is 130 milliamperes when operating from a 12-volt storage battery. There is no line or local drain on the power supply, when the repeater is idle (marking) and set up for unattended service, other than the drain required for power supply losses when using an a-c power supply or a 12-volt storage battery. Data regarding alternating-current and direct-current (gasoline-engine power unit) power requirements and battery-life data are given in table I.

Table I. Power Requirements.[1]

Source	Requirements		
	Repeater	Teletypewriter	Total
115-volt or 230-volt alternating current.	70 watts..	120 watts.	190 watts
115-volt direct current (gasoline-engine power unit).	25 watts..	90 watts..	115 watts
115-volt direct current from dry batteries (BA–26, or equivalent).	([2])	([3])	([2])
12-volt storage battery (BB–55, or equivalent).	.....	.....	.....
Without manual telegraph set:			
Idle, line A and line B marking.	1.5 amps.	([3])	1.5 amps
Repeating from line A to line B or from line B to line A.	2 amps...	([3])	2 amps
With manual telegraph set:			
Idle, line A and line B marking.	1.5 amps.	([3])	1.5 amps
Sending to terminal A and to terminal B at the same time.	3 amps...	([3])	3 amps

[1] Based upon average usage except as noted.

[2] Battery life at 70° with repeater operating 12 hours a day at 30 words per minute is 4 to 6 days. Battery life depends on temperature as follows:

Temperature	*Percent total battery life*
70° F.	100
40° F.	69
32° F.	48

[3] Teletypewriter cannot be used when operating on battery supply.

Section II. APPLICATION OF REPEATER TG-31 (INTERMEDIATE, TELEGRAPH)

8. General

The line side of Repeater TG-31 is designed for type B polarential operation (differential-sending only). Hereafter in this manual type B polarential will be referred to as polarential. All equipments connected to Repeater TG-31 at the distant ends of the lines must be set up for polarential operation (polar-sending) to work with Repeater TG-31. The various equipments with which Repeater TG-31 will function and operating distances for some of the more common types of line conductors are covered in the following paragraphs.

9. Line Operation

Figure 8 is a general schematic diagram showing typical system applications of Repeater TG-31. The system may consist of a Repeater TG-30, with local teletypewriter equipment, on each end of the system, or it may consist of Repeater TG-30 on one end of the system and a carrier telegraph terminal located on the other end. Repeater TG-31 is located about midway between the two terminals. Only one Repeater TG-31 can be used in the line circuit between the two terminals. A teletypewriter may be connected to Repeater TG-31. Telegraph Repeater OA-6/FC (d-c telegraph repeater packaged equipment X-61824A) may be used in place of Repeater TG-30.

Note. In this manual the term "carrier telegraph terminal" is used to indicate the following equipment:

Telegraph Terminal CF-2-A (Carrier).
Telegraph Terminal CF-2-B (Carrier).
Telegraph Terminal CF-6 (Carrier).
Telegraph Terminal TH-1/TCC-1.
Carrier Terminal OA-4/FC (V-f carrier telegraph packaged equipment X-61822A).
Carrier Terminal OA-5/FC (V-f carrier telegraph packaged equipment X-61822B).

10. Local Operation

Two types of local operation are possible at Repeater TG-31. The first of these is with Teletypewriter TG-7-B, or equivalent (par. 5*b*), connected directly to Repeater TG-31. The teletypewriter may be used either for monitoring through transmission or as a terminal station. The second type of local operation is using the manual telegraph set which is a part of Repeater TG-31. For this type of operation a manual telegraph set must be used at the terminal repeaters. Repeater TG-30 contains a built-in manual telegraph set.

11. System Operating Ranges

a. General. The operating distances that may be obtained with systems using Repeater TG-31 will be determined by the type of equipment with which it is operating and the type of line conductors over which it is operating.

b. Line Conductors. The repeater may be operated on all types of line conductors, the more common of which are as follows:

(1) Field Wire W-110-B, simplexed.
(2) Field Wire W-143, simplexed.
(3) Spiral-four cable, simplexed.
(4) Wire W-74 (104 copper), open-wire line, composited.
(5) Wire W-153 (080 copper-steel (40 percent)), open-wire line, composited.
(6) 104 copper-steel (40 percent), open-wire line, composited.

Open-wire circuits may be operated simplexed as well as composited.

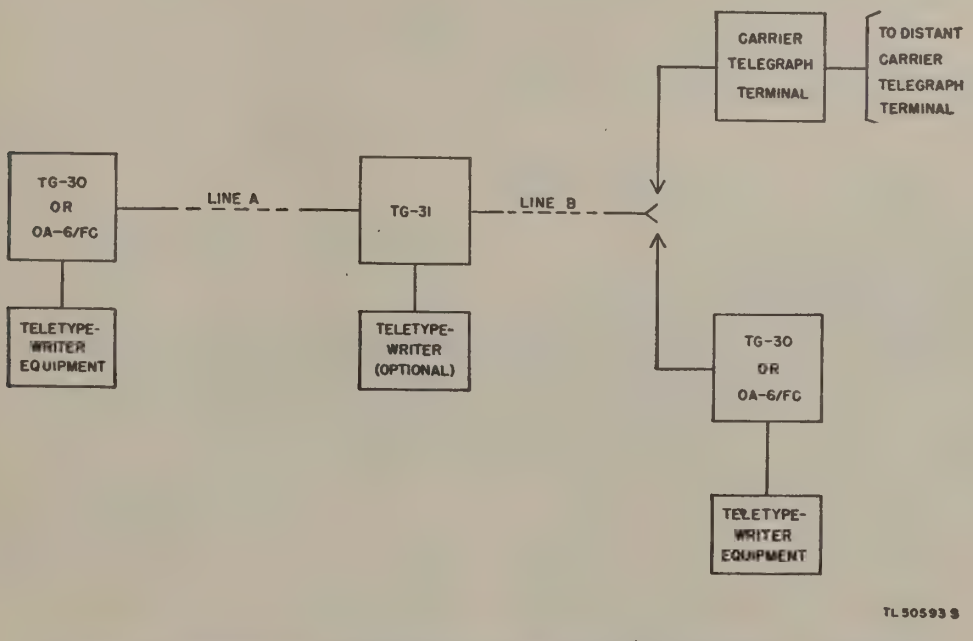


Figure 8. Typical system applications of Repeater TG-31 (Intermediate, Telegraph).

Table II. Guide for determining operating ranges. (368 operations per minute) [1]

	W–110–B simplexed (miles)	W–143 simplexed (miles)	Spiral-four cable simplexed [2] (miles)	W–74 composited [3] (miles)	W–153 composited [3] (miles)	104 copper-steel (40%) composited [3] (miles)
TG–31 to TG–30 or to OA–6/FC.	40.....	40.....	50.....	200.....	50.....	100
TG–31 to a carrier telegraph terminal.	25.....	40.....	50.....	[4].....	[4].....	[4]

[1] At 404 operations per minute, the operating range for a line section with Repeater TG–31 and Repeater TG–30 is 30 miles on Wire W–110–B. The range for Wire W–143 and spiral-four cable at 404 operations per minute is 35 miles. The operating ranges for open wire listed above are the same for 368 opm and 404 opm.

[2] Suitable for one telegraph circuit per cable without d-c signaling circuit. When other pair is used for d-c signaling circuit, operation should be limited to two 25-mile sections in order to prevent errors in teletypewriter copy due to operation of the signaling circuit.

[3] For maximum lengths of simplexed open wire use 100 miles or *twice* the maximum length for composited wire, whichever is less.

[4] Field-wire lines are assumed for d-c extension facilities from carrier telegraph terminals.

c. Operating Ranges. The operating ranges in table II are provided as a guide in laying out circuits. They should not be used as absolute operating ranges under all conditions.

d. Reduction of Operating Ranges. The presence of earth potential, powerline induction, or ground resistance tend to reduce operating ranges. The distances given for operation on field-wire circuits are based on adverse weather conditions with wire laid on the ground and with a capacitance to ground in order of 0.8 microfarad per mile and leakage resistance to ground of ¼ megohm per mile. The distances given for open-wire lines are based on a leakage resistance to ground of ¼ megohm per mile and a leakage resistance of 3½ megohms per mile between the wires of a pair. In case the leakage resistance between wires of a pair is substantially less than 3½ megohms per mile, it may not be possible to use the pair for more than one telegraph circuit.

Section III. UNPACKING, SETTING-UP, AND REPACKING INSTRUCTIONS

12. Location of Equipment

a. Before starting any installation, decide upon the general layout in view of local conditions. The equipment should be located so as to provide maximum protection for the equipment and operating personnel. When the equipment must be located in tents or temporary buildings, select the site with the least chance of being flooded, and, if boards or planks are available, construct a secure platform to be used as a base for the equipment. Areas which are likely to become extremely dusty should also be avoided. If possible, choose a location near a good source of ground.

b. When several repeaters, or other equipment, are located at a common point, they should be arranged in convenient alignment to prevent confusion in operating and maintaining the equipment.

c. Wiring to the repeater, to other equipment, and to power equipment should be carried overhead when possible and should be so arranged that it will not be damaged and will not be a hazard to traffic during normal operation. In special cases it may be advisable to bury the wiring and cables in the ground if no other suitable protection is available.

d. When a power unit is used, it should be located outside the building, tent, or other structure, so that exhaust fumes will not be hazardous to the operating personnel. The power wiring should be separated from, and run independently of, the transmission wiring between equipments.

13. Uncrating, Unpacking, and Checking (figs. 9 and 10)

a. The components of Repeater Set TC-19 (Intermediate, Telegraph) are packed in two separate cases. Repeater TG-31 is packed in one case, and the two Ground Rods MX-148/G are packed in the other case. Physical dimensions for each of the units packed for export are shown in table III.

Table III. Packing data.

Unit	Dimensions (in.)	Weight (lb)	Shipping space (cu ft)
Repeater TG–31...	34 x 25⅛ x 23⅛..	160..	11.5
Ground Rods MX–148/G (two rods per case).	77½ x 7¾ x 5....	26..	1.73

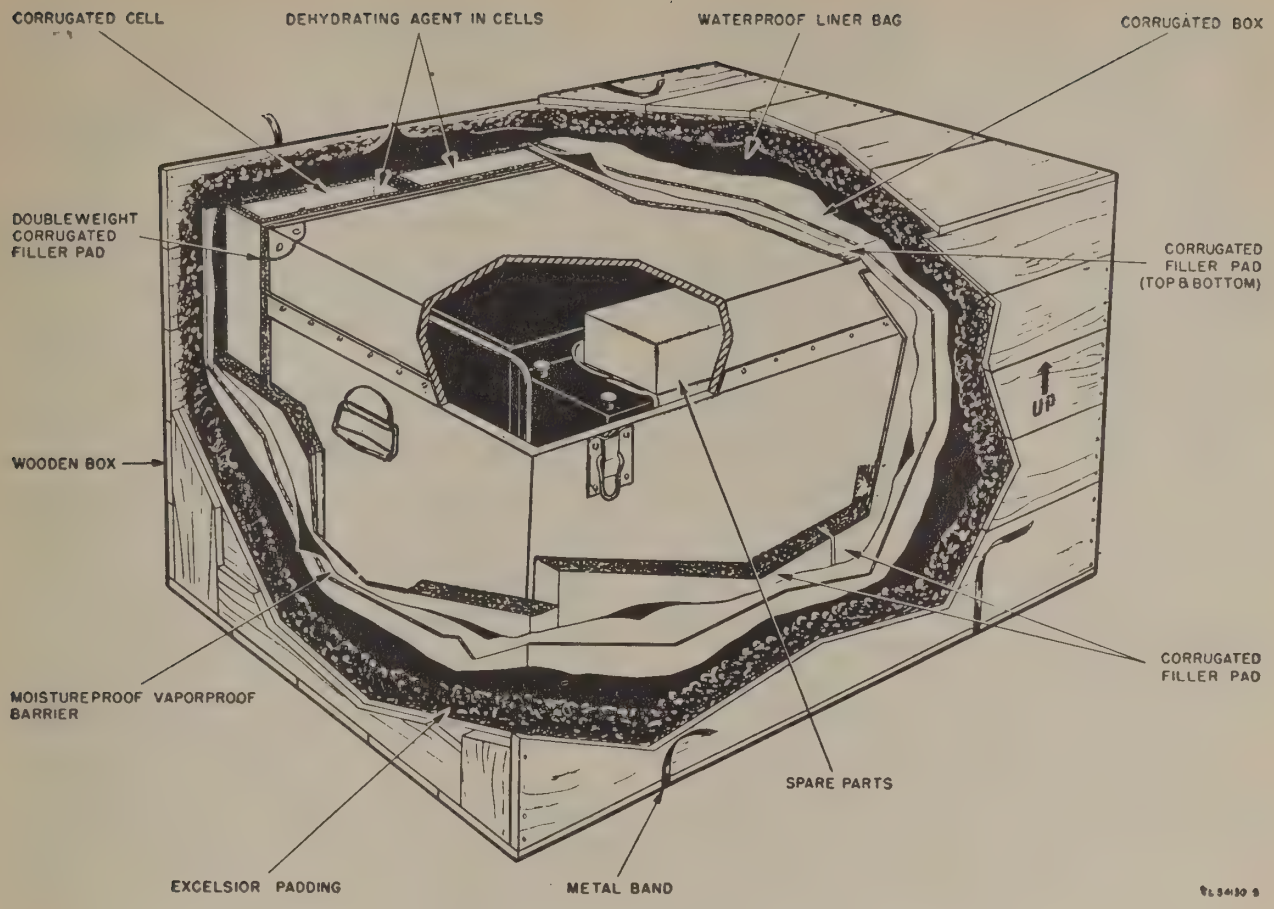


Figure 9. Packing details, Repeater TG-31 (Intermediate, Telegraph).

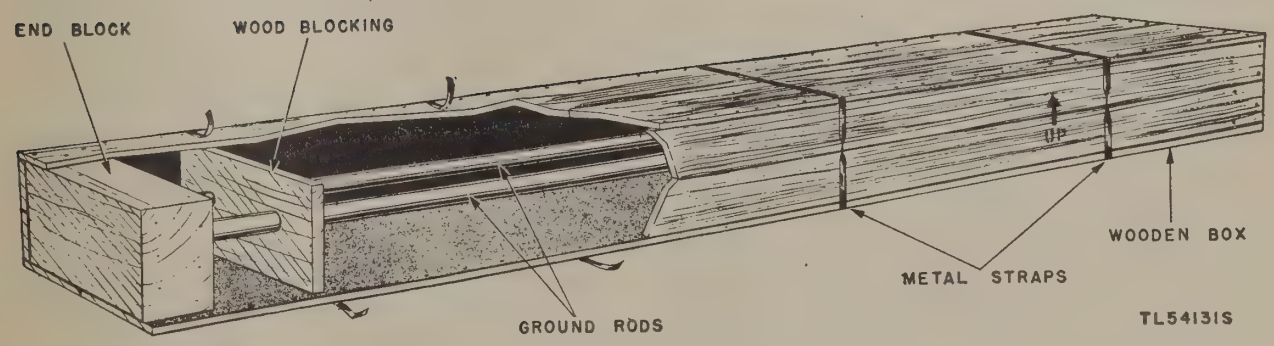


Figure 10. Packing details, Ground Rods MX-148/G.

b. Be careful when unpacking or handling the equipment because it may be damaged easily when not protected by the packing case. In unpacking the equipment, follow the steps outlined below.

(1) Place the packing case as near the operating location as is convenient.

(2) Cut the steel straps.

(3) Remove the nails, using a nail puller, and remove the sides and top of the packing case. *Prying the sides and top off may result in damage to the equipment.*

(4) Remove the liner bag, the moistureproof barrier, and the corrugated paper that cover the equipment inside the case.

Caution: When removing waterproofing and other protective wrappings, be careful not to remove moistureproofing and fungiproofing coatings.

(5) Remove the equipment from its case and place it near its final location.

(6) Thoroughly inspect the equipment and spare parts for possible damage during shipment.

(7) Check the components of the set against the master packing slip and against the list of components in appendix I.

c. Immediately after Repeater TG-31 is unpacked, the gas adsorber units for the polar relays should be installed or replaced (par. 72).

14. Repacking Instructions

a. If this equipment is to be repacked for troop movements or is to remain out of service for some time, all line, local, and power connections should be removed, the power cord coiled inside the case, and the cover closed and fastened.

b. If the repeater is to be placed in storage the following steps should be taken:

(1) Disconnect the power cord and coil the cord inside the case. Disconnect all wiring to the binding posts. If teletypewriter power and transmission cords are connected they should be disconnected.

(2) Secure in place all spare parts and any loose parts.

(3) Place technical manuals in the canvas pocket and fold pocket over repeater panel.

(4) Close the cover and fasten in place.

(5) Place the repeater in a dry location.

(6) Inspect at reasonable intervals to see that the equipment is clean, free from rust, and has not been damaged. Clean and repair if necessary.

(7) If the equipment is left in storage for more than 18 months, the electrolytic filter capacitors of the power supply lose their film and should be restored (par. 73).

PART TWO

OPERATING INSTRUCTIONS

Note. For information on destroying this equipment to prevent enemy use, see the destruction notice at the front of this manual.

Section IV. EQUIPMENT CONNECTIONS AND INITIAL ADJUSTMENTS

15. General

Before Repeater TG-31 can be placed in service and the system lined up for operation, the equipment must be connected and the power supply arranged for the external power source. Connections are required between Repeater TG-31 and the lines, between the repeater and teletypewriter (when used), to the power supply, and to ground. Connections to the lines, local equipment, and ground are covered in paragraphs 16, 17, and 18. Power supply arrangements and connections are covered in paragraph 19. Equipment and line checks are covered in paragraph 20.

Caution: Connections should not be made to the external power supply until the line and local connections have been made and the power switches have been set for the source of power available.

16. Grounding Arrangements

a. A ground is required at the repeater to supply the return circuit for the line connections and to minimize the hazard to the equipment and personnel from lightning and other sources of high voltage.

b. Since the repeater operates on ground-return circuits, the resistance of the connection to earth is equal in importance to the resistance of the metallic-line conductor. Every effort should be made to obtain the best ground available in the area where service is to be established. Where a buried water-supply piping system is available the repeater equipment should be grounded to it. Use No. 14 gauge wire or its equivalent, although a larger gauge wire may be required for mechanic strength. It is preferable to run a ground lead a few miles to a water pipe system rather than to drive ground rods in soil not well covered with vegetation or in dry soil.

c. When a buried water-supply piping system cannot be used for a ground, the best practical ground should be used. For example, use buried gas pipes, underground tanks, or other buried metallic structures, or driven rods. When driven rods are used they should be driven to their full length and, except when the earth is moist, drive two rods at least 25 feet apart. For detailed information on approved grounding procedures see TM 11-755.

17. Connections to the Line

The external connections to Repeater TG-31 for line operation are shown in figures 11 and 12. During periods of unattended service the external wiring should be brought into and out of the case through the weatherproof joint between the cover and the case of the equipment. This allows the cover to be closed during operation. The following connections should be made to the equipment:

a. Connect the GND binding post to ground, established as specified in paragraph 16.

b. Connect the line wires to the line binding posts as follows:

(1) For operation with Repeaters TG-30 at the distant terminals (fig. 11), connect the line wire from distant terminal A to the Repeater TG-31 LINE A binding post, and connect the line wire from distant terminal B to the Repeater TG-31 LINE B binding post. The line wire should be connected to LINE 1 binding post at Repeater TG-30.

(2) For operation with a carrier telegraph terminal at one end of the line and Repeater TG-30 at the other end of the line (fig. 12), connect the line wire from the carrier telegraph terminal (terminal A) to the Repeater TG-31 LINE A binding post and the line wire from Repeater TG-30 to the Repeater TG-31 LINE B binding post. If the carrier telegraph terminal is designated terminal B, the line from the carrier telegraph terminal should be connected to the Repeater TG-31 LINE B binding post and the line from Repeater TG-30 should be connected to the Repeater TG-31 LINE A binding post. At Repeater TG-30 the line wire should be connected to the LINE 1 binding post. At the carrier telegraph terminal the line wire should be

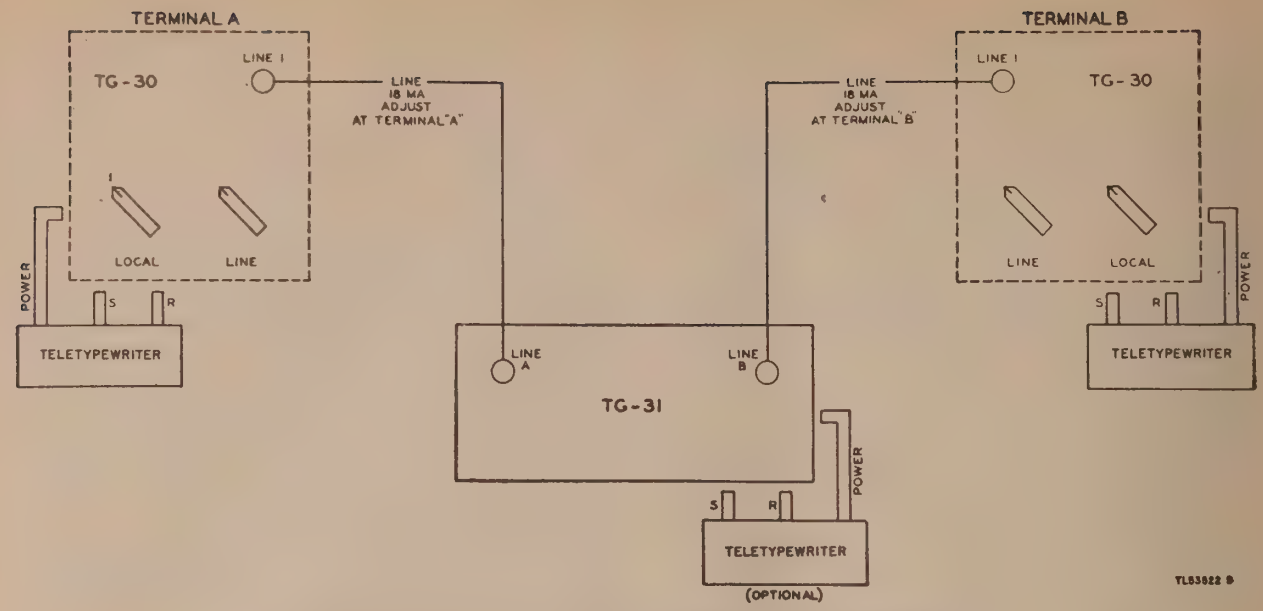


Figure 11. Operation with Repeaters TG-30 at distant terminals.

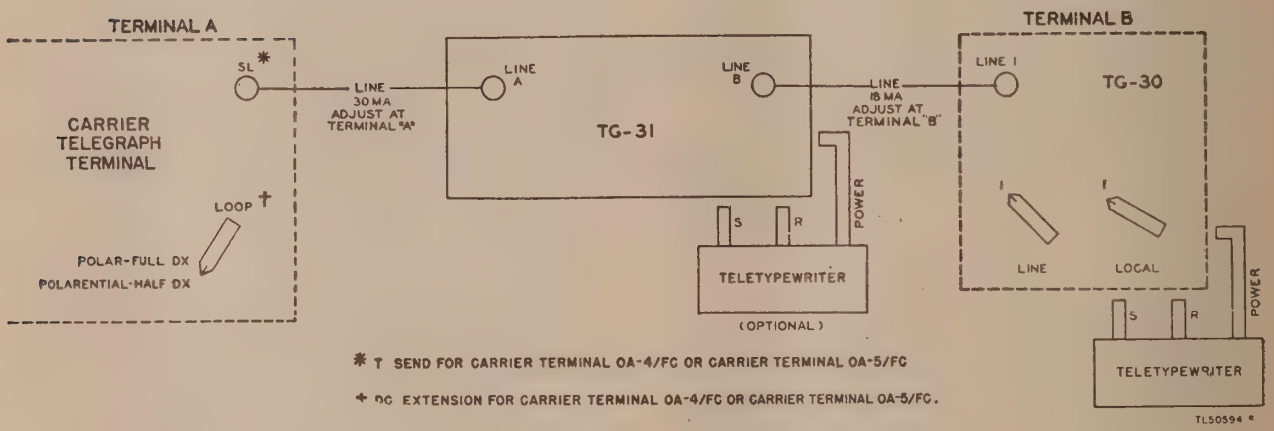


Figure 12. Operation with a carrier telegraph terminal and a terminal using Repeater TG-30.

connected to the SL binding post of Telegraph Terminal CF-2-A, Telegraph Terminal CF-2-B, Telegraph Terminal CF-6, or Telegraph Terminal TH-1/TCC-1. If Carrier Terminal OA-4/FC or OA-5/FC is used, the line wire should be connected to the T SEND terminal.

18. Connections to Local Equipment

a. General. A Teletypewriter TG-7-B, or equivalent (par. 5*b*), can be used as local equipment, or if no teletypewriter equipment is available the manual telegraph set (part of Repeater TG-31) may be used for local operation.

b. Local Operation with Teletypewriter TG-7-B. (1) For local operation with Teletypewriter TG-7-B connect the teletypewriter cord with the red plug to the PRINTER jack marked RED R. This is the receiving magnet circuit. Connect the teletypewriter cord with the black plug to the PRINTER jack marked BLK S. This is the sending contacts circuit. Connect the teletypewriter power cord to the receptacle marked PRINTER POWER. This receptacle supplies power (par. 19*a*) to the teletypewriter motor.

Note. Teletypewriter cannot be used when the repeater is operating on battery supply.

(2) When the teletypewriter has been connected as described above, operation of its keyboard sends

to both distant terminals and makes a local copy at the intermediate repeater. The teletypewriter will print a local copy of transmissions passing through from either distant terminal.

(3) Personnel connecting the teletypewriter should check to see that the range finder is set in the position (usually between 50 and 55 on the scale) determined by the maintenance personnel.

Note. If wire other than Wire W-110-B is used and the speed is 404 opm, best results will usually be obtained if the range finder is set at 50.

c. Local Operation with Manual Telegraph Set. For local operation with the manual telegraph set remove all the teletypewriter cords and connect the headset to the HEADSET jack. When the distant terminal is using a teletypewriter, send a number of long dashes as a signal that manual telegraph operation is desired. The distant teletypewriter will run *open* while the key is held down. The telegraph key sends to both terminals at the same time and signals from either terminal (one at a time) are received in the headset. Adjustments required on the manual telegraph set are made as follows:

(1) *Telegraph key.* (*a*) Loosen the locknuts on the four adjusting screws.

(*b*) Operate the key slowly and adjust the screws on either side of the frame until the key lever moves freely without sidewise motion. Tighten the locknuts on these two screws.

(*c*) Turn the adjusting screw on the rear of the key lever until the back contact closes when the key is unoperated and opens when it is operated, and the desired clearance is obtained between the front contacts. Tighten the locknut.

(*d*) Adjust the screw on the front of the key lever until the desired spring tension is obtained. Tighten the locknut.

Caution: When adjusting the telegraph key for proper travel, *do not* reduce the travel to the extent that the front and rear contacts are closed at the same time. Failure to observe this caution will result in blowing fuse A because simultaneous closing of the front and rear contacts short-circuits the power supply by putting a ground on the +115-volt lead to the telegraph key.

(2) *ADJ TONE knob.* While operating the telegraph key, turn the knob designated ADJ TONE to its extreme counterclockwise position and then turn slowly in the clockwise direction until a satisfactory tone is obtained. Variations in characteristics of component parts because of less rigid wartime manufacturing specifications, particularly the neon TONE lamps, may result in the neon TONE lamp failing to oscillate when the ADJ TONE knob is turned to its extreme clockwise position.

19. Power Supply Arrangements (fig. 13)

a. Power Connections for A-c Supply or D-c Gasoline-engine Power Unit with or Without Teletypewriter. When a local teletypewriter is connected, the required power supply is 115- or 230-volt alternating current, 50- to 60-cycle, or 115-volt direct current (gasoline-engine power unit). Check reliability of power supply and arrange repeater as follows:

(1) *With 115-volt a-c power supply.* Open door at right-hand side of rectifier panel. Throw the right-hand toggle switch to 115/230V AC position and throw the left-hand toggle switch to 115V AC position. Throw the power switch on the repeater unit to position designated 115V OR 230V AC OR 12V DC. Connect power cord to the power supply. Hold down MEAS VOLTS key and turn ADJUST VOLTS knobs COARSE and FINE until meter indicates 115 volts if teletypewriter is connected, or 127 volts without teletypewriter.

(2) *With 230-volt a-c power supply.* Open door at right-hand side of rectifier panel. Throw right-hand toggle switch to 115/230V AC position and throw left-hand toggle switch to 230V AC position. Throw power switch on repeater unit to 115V OR 230V AC OR 12V DC position. Connect power cord to power supply. Hold down MEAS VOLTS key and turn ADJUST VOLTS knobs COARSE and FINE until meter indicates 115 volts if teletypewriter is connected or 127 volts without teletypewriter.

Caution: *Serious damage may result to the repeater or connected teletypewriter if 115V AC - 230V AC switch is not operated to the 230V AC position when power supply is 230-volt ac.*

(3) *With 115-volt d-c supply (gasoline-engine power unit).* Throw power switch on repeater unit to 115V DC position. Connect power cord to output of external power supply. The voltage of this power supply should be 115 volts as shown on the meter on Repeater TG-31. Repeater TG-31 is not equipped with a means of adjusting the voltage when using a d-c gasoline-engine power unit. Hold down MEAS VOLTS key to check the voltage and, if meter shows no indication, reverse the plug connected to the generator receptacle. Check the voltage supplied to the repeater by holding down the MEAS VOLTS key, with the teletypewriter connected and running when a teletypewriter is used.

Adjust and maintain voltage at 115 volts during service periods by means of controls on the gasoline-engine power unit.

b. Power Connections for Battery Power Supplies. (1) *General.* Unattended operation is defined as service without supervision by a repeaterman or other attendant. Such operation requires the use of 115-volt dry batteries or a 12-volt storage battery for the power supply. No provision is made for operation of a teletypewriter when using these power supplies. See paragraph 7, table I, for battery-life data. The condition of the batteries should be checked before starting service. All batteries should be covered to prevent the accumulation of moisture on the terminals. Connections and arrangements of the batteries are covered in the following subparagraphs.

(2) *Using 115-volt dry batteries.* The dry batteries may be 45-volt B Batteries BA-26, or equivalent. Connect three batteries in series. Throw the power switch on the repeater unit to the 115V DC position. Connect batteries to the 115V DRY BAT terminals (positive and negative as designated). Make all battery connections secure. Hold down MEAS VOLTS key, and, if the batteries are new, the voltage will be about 135 to 140 volts. This voltage is higher than the required 115 volts but will give satisfactory operation. Remove batteries when voltage drops to 35 volts for each battery or a total of 105 volts. Connecting two banks of batteries in parallel more than doubles the life of one bank of batteries. The power cord must not be connected when using these batteries.

(3) *Using 12-volt storage battery.* One 12-volt storage Battery BB-46, or preferably, two 6-volt Batteries BB-55, or equivalents, connected in series may be used. Connecting two banks of batteries in parallel more than doubles the life obtained from a single bank of batteries. Open door on right-hand side of rectifier power-supply unit panel and throw right-hand toggle switch to 12V STORAGE BAT position. Throw power switch on repeater unit to the position designated 115V OR 230V AC OR 12V DC. Connect storage battery leads, according to positive and negative terminal designations, to 12 V STORAGE BAT terminals. Each lead

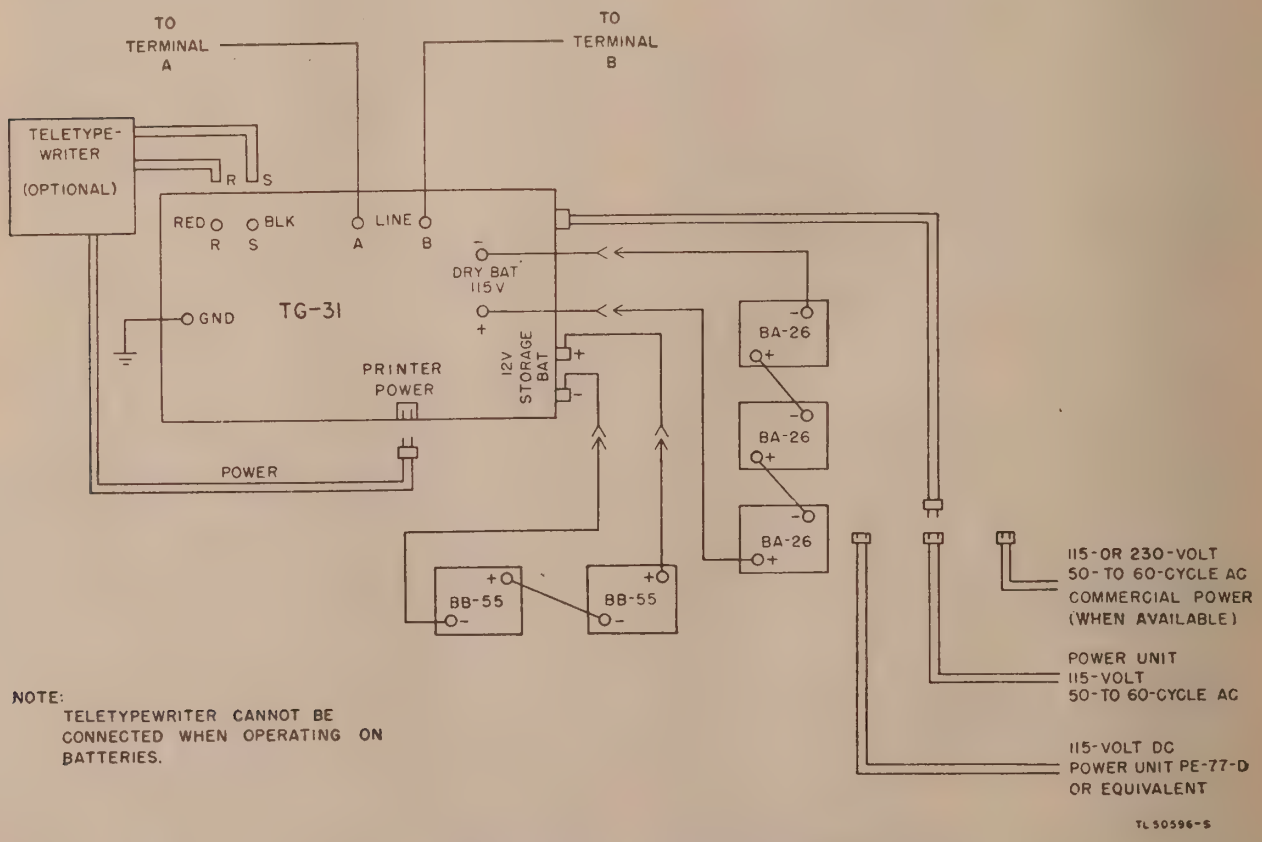


Figure 13. Cording diagram of power supply arrangements for Repeater TG-31 (Intermediate, Telegraph).

should be at least No. 14 wire and not more than 4 feet long. Turn ADJUST VOLTS knobs COARSE and FINE until meter reads 127 volts while holding down MEAS VOLTS key. Check voltage during service periods and remove batteries when it is impossible to obtain a voltage of 115 with ADJUST VOLTS knobs in the extreme counterclockwise position.

20. Equipment and Line Checks

a. Before placing the repeater in service, the polar relays in Repeater TG-31 should be checked. Test Set I-193-A should be used for testing and readjusting the polar relays. For detailed procedure on testing and adjusting the polar relays, refer to TM 11-2513. Check to see that gas adsorber units in good condition (par. 33*b*(3)) are installed in the relays.

b. To check the line to terminal B, turn the CUT LINE A knob clockwise and try to communicate with terminal B. Return the CUT LINE A knob to its former position when test has been completed. To check the line to terminal A, turn the CUT LINE B knob clockwise and try to communicate with terminal A. Be sure to restore both CUT LINE A and CUT LINE B knobs to the normal position when the circuit is suitable for through service. In this position the lines on the CUT LINE knobs are horizontal, as shown in figure 4. Turning of the CUT LINE A knob prevents through transmission from line A to line B but not from line B to line A. Turning of this knob also allows sending from the local teletypewriter or telegraph key to line A and line B and reception on the teletypewriter or in the headset from line B. Turning of the CUT LINE B knob prevents through transmission from B to A, but not from A to B, allows sending from the local teletypewriter or telegraph key to A and B, and allows reception from line A. Turning of *both* CUT keys prevents through transmission in both directions and allows sending to both lines at the same time and prevents reception from either line.

Section V. SYSTEM LINE-UP

21. System Line-Up

No system line-up is required at Repeater TG-31 since all line current adjustments are made at the terminal equipments. Placing the system in service may require communication with personnel at the distant terminals. If means other than the equipment being lined up are available, use such means to communicate. If other means of communication are not available, the monitoring teletypewriter or the manual telegraph set may be used for this purpose. During the system line-up the distant terminals may request Repeater TG-31 to send a spacing signal by holding down the break key of the teletypewriter, or otherwise sending a long spacing signal.

Section VI. SUMMARY OF PROCEDURE FOR PLACING EQUIPMENT IN SERVICE

22. Line-Up Procedure

The steps required to place Repeater TG-31 into service and the order in which they should be performed is as follows (fig. 14):

a. Connect ground wire to GND binding post (1).

b. Connect line wire to distant terminal A to LINE A binding post (4), and connect the line wire to distant terminal B to LINE B binding post (5).

c. For local operation with Teletypewriter TG-7-B, or equivalent, connect red plug to PRINTER RED R jack (2). Connect black plug to PRINTER BLK S jack (3). Connect teletypewriter power cord to PRINTER POWER receptacle (8).

d. Make power supply arrangements as follows:

(1) With 115-volt a-c power supply, open panel (13) and throw switch (14) to 115/230V AC and throw switch (15) to 115V AC. Throw power switch (11) to 115V OR 230V AC OR 12V DC position.

(2) With 230-volt a-c power supply, open panel (13) and throw power switch (14) to 115/230V AC and throw switch (15) to 230V AC. Throw power switch (11) to 115V OR 230V AC OR 12V DC position.

(3) With 12-volt d-c power supply (storage battery), open panel (13) and throw switch (14) to 12V STORAGE BAT position. Throw power switch (11) to 115V OR 230V OR 12V DC position.

Note. Teletypewriter cannot be used when operating on battery supply.

(4) With 115-volt d-c power supply, throw power switch (11) to 115V DC position.

e. Make connections to power supply as follows:

(1) With 115-volt or 230-volt alternating current or 115-volt d-c gasoline-engine power unit supply, connect power cord (9) to power supply.

(2) With 12-volt storage battery supply, connect + and — battery terminals to 12V STORAGE BAT binding posts (12). Use No. 14 wire and not more than 4 feet for each lead.

(3) With 115-volt dry batteries and the power supply, connect + and — battery terminals to 115V DRY BAT binding posts (10). Three 45-volt batteries may be used in series.

f. Adjust voltage of power supply as follows:

(1) With 115- or 230-volt alternating current or a 12-volt storage battery, adjust the voltage by holding down the MEAS VOLTS key (6) and turning the ADJUST VOLTS knobs (16) until meter reads 115V if local teletypewriter is connected or 127 volts without teletypewriter.

(2) With 115-volt direct current (gasoline-engine power unit), hold down the MEAS VOLTS key (6) and adjust voltage at the source so that Repeater TG-31 meter reads 115V.

(3) With 115-volt dry batteries, hold down MEAS VOLTS key (6) and check voltage. Three new B batteries will give at least 135 volts.

g. Maintain voltage as specified in *f* above for 115- or 230-volt alternating current, a 12-volt storage battery, or 115-volt direct current. Replace storage battery when unable to obtain 115V with ADJUST VOLTS knobs COARSE and FINE in extreme left position. Replace dry batteries when voltage drops to 105 volts.

h. For manual telegraph operation remove all teletypewriter cords. Connect headset to HEADSET jack (17). Turn ADJ TONE knob (7) to suit using personnel while operating telegraph key.

i. If LINE A is out of service, turn CUT LINE A key (18) clockwise and communicate with terminal B. If LINE B is out of service turn CUT LINE B key (19) clockwise and communicate with terminal A. *Restore* CUT LINE keys to original position when lines are again ready for service.

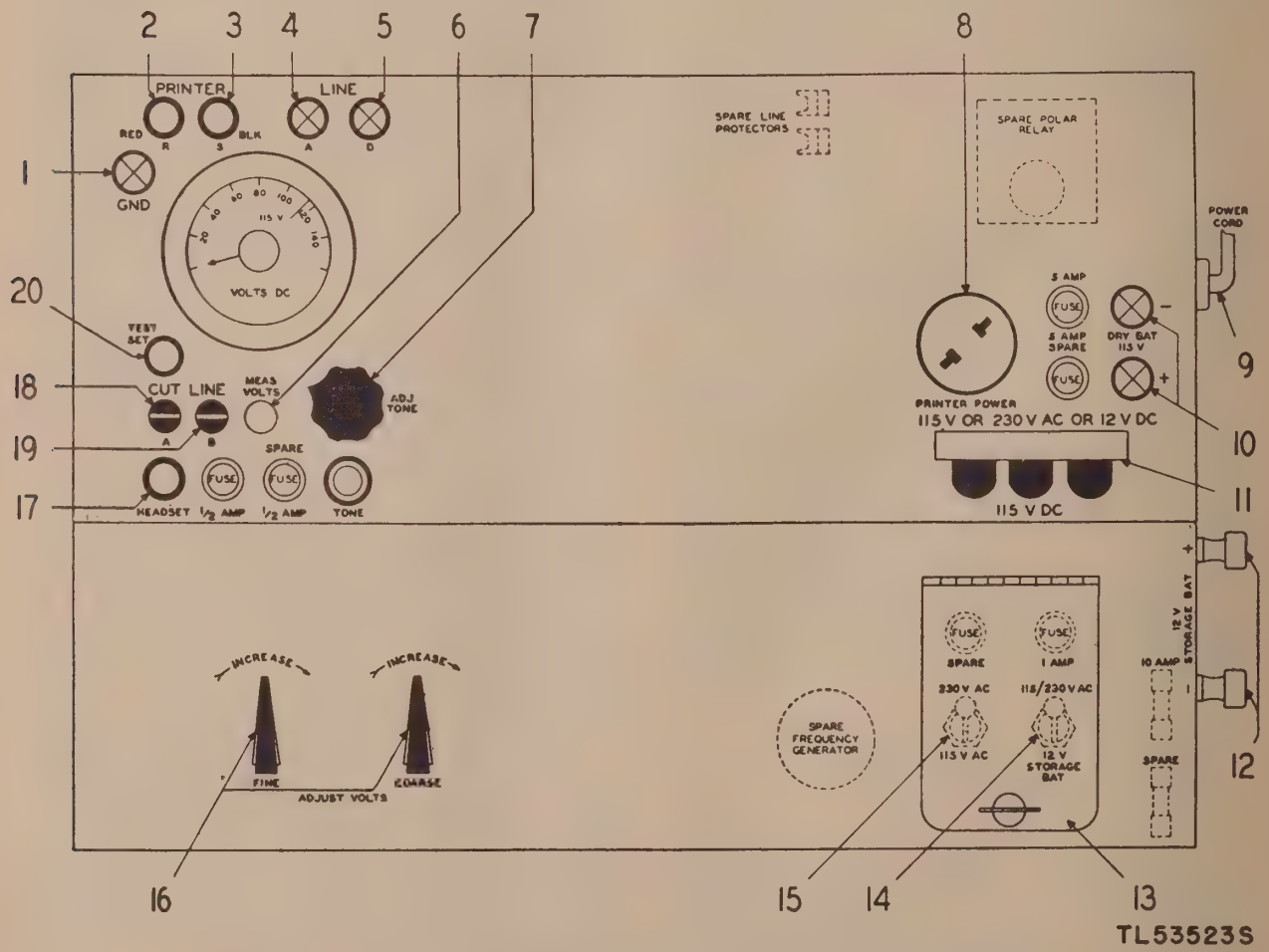


Figure 14. Diagram of top panel of Repeater TG-31 (Intermediate, Telegraph).

Section VII. ROUTINE CHECKS OF PERFORMANCE

23. Records

a. It is advisable at each repeater to maintain a record showing when each periodic test is made, the troubles found, and when and how they are cleared. Such records will indicate which equipment and circuits should be given the most attention and it may also be useful in locating conditions causing circuit failures.

b. Forms for recording such data may be improvised and should be made to cover transmission in both directions and operating checks and adjustments. These forms may be designed to cover the results for a single day, or for several days if experience indicates that the number of adjustments permits such usage. The suggested forms given below may be changed to suit using personnel.

24. Purpose and Use of Check List

a. GENERAL. The equipment performance check list (par. 25) will help the operator determine whether Repeater TG-31 is functioning properly. The check list gives the item to be checked, the conditions under which the item is checked, the normal indications, and the corrective measures that the operator can take. Items 4 to 12 correspond to the initial steps performed to place the repeater in service and are checked when the system is about to go into operation after having been shut down. Item 13 is a check which is made while the equipment is in operation.

b. ACTION OR CONDITION. For some items the information given in the action or condition column consists of the connections that must be checked. For other items it represents an action that must be taken in order to check the normal indication given in the normal indication column.

TROUBLE RECORD

Reported				Cleared			
Date	Time	By			Date	Time	By
3 Jan..	1600.	PRD	System out of service.	Replaced broken wire to LINE A binding post.	3 Jan.	1800.	PRD
10 Jan..	0915.	REE	No d-c output, operating on storage battery.	Replaced frequency generator.	10 Jan.	1000.	REE
20 Jan..	1300.	JFB.	Errors in local teletypewriter copy.	Replaced receiving relay R.	20 Jan.	1320.	JFB.

OPERATING CHECKS

Date	Storage battery voltage	Dry battery voltage	D-c voltage —a-c supply	Relays checked
3 Jan.....	127.....	.....	.....	OK
7 Jan.....	110.....	.....	.....	.....
7 Jan.....	.....	135.....	.....	.....
11 Jan.....	.....	108.....	.....	.....
11 Jan.....	.....	.....	115.....	.....
14 Jan.....	.....	.....	115.....	.....
18 Jan.....	.....	.....	115.....	.....
20 Jan.....	.....	.....	115.....	R relay bad.

c. NORMAL INDICATIONS. The normal indications include the visible and audible signs that the operator will find when he checks the items. If the indications are not normal, the operator should apply the recommended corrective measures.

d. CORRECTIVE MEASURES. The corrective measures listed are those that the operator can make without turning the equipment in for repairs. If the recommended corrective measures do not yield results, trouble shooting by an experienced repairman is necessary. If the tactical situation requires that communication be maintained, however, and if the set is not completely inoperative, the operator must maintain the set in operation as long as it is possible to do so.

25. Equipment Performance Check List for Repeater TG-31 (Intermediate, Telegraph)

	Item No.	Item	Action or condition	Normal indication	Corrective measures
PREPARATORY	1...	GND binding post...	Ground wire connected to GND binding post.		
	2...	LINE binding posts..	Line wires connected to LINE A and LINE B binding posts.	Line to terminal A connected to LINE A, and line to terminal B connected to LINE B.	Connect lines to correct binding posts.
	3...	PRINTER jacks....	Teletypewriter (when used) cords plugged into PRINTER jacks.	Red plug in RED R jack and black plug in BLK S jack.	Connect plugs into correct jacks.
START	4...	115V OR 230V AC OR 12V DC-115V DC switch.	A-c power supply or 12-volt storage battery.	Switch on 115V OR 230V AC OR 12V DC position.	Operate switch to correct position for power supply used.
			115-volt direct current (gasoline-engine power unit, or dry battery).	Switch on 115V DC position.	
	5...	115/230V AC - 12V STORAGE BAT switch.	A-c power supply.....	Switch on 115/230V AC position.	Operate switch to correct position for power supply used.
			12-volt storage battery.....	Switch on 12V STORAGE BAT position.	
	6...	115V AC-230V AC switch.	115-volt a-c supply.....	Switch on 115V AC position.	Operate switch to correct position for power supply used.
			230-volt a-c supply.....	Switch on 230V AC position.	
	7...	Power cord.....	A-c power supply or 115-volt d-c (gasoline-engine power unit) supply.	Connected to power supply.	
	8...	12V STORAGE BAT binding posts.	12 - volt storage battery supply.	The + battery terminal connected to + designation and — battery terminal connected to — designation.	Reverse connections if not properly connected.
	9...	115V DRY BAT binding posts.	115-volt dry battery supply.	The + battery terminal connected to + designation and — battery terminal connected to — designation.	Reverse connections if not properly connected.
	10..	MEAS VOLTS key	Hold down.....	Meter reading: 127 volts without local teletypewriter, when operating with a-c or 12-volt storage battery supply. Meter reading: 115 volts with local teletypewriter, when operating on a-c supply.	Adjust voltage to required value with ADJUST VOLTS knobs.

	Item No.	Item	Action or condition	Normal indication	Corrective measures
START				Meter reading: 115 volts. (115-volt, gasoline-engine power unit, d-c supply.)	Adjust voltage at source.
				Meter reading: 135 volts. (New dry batteries.)	Replace dry batteries when voltage drops to 105 volts.
	11..	Headset.....	Insert plug in HEADSET jack. Hold down telegraph key.	Tone in headset.....	Replace NEON lamp if tone cannot be obtained by adjusting ADJ TONE knob.
	12..	ADJ TONE knob...	Hold down telegraph knob..	Tone in headset.....	Adjust to suit using personnel.
EQUIPMENT PERFORMANCE	13..	MEAS VOLTS key.	Hold down.....	Meter reading: 127 volts without local teletypewriter, when operating with a-c or 12-volt storage battery supply. Meter reading: 115 volts with local teletypewriter, when operating on a-c supply.	Adjust voltage to required value with ADJUST VOLTS knobs. Replace storage batteries if 115 volts cannot be obtained.
				Meter reading: 115 volts. (115-volt, gasoline-engine power unit, d-c supply.)	Adjust voltage at source.
				Meter reading: 135 volts. (New dry batteries.)	Replace dry batteries when voltage drops to 105 volts.

PART THREE

PREVENTIVE MAINTENANCE

Section VIII. PREVENTIVE MAINTENANCE TECHNIQUES

26. Meaning of Preventive Maintenance

Preventive maintenance is a systematic series of operations performed periodically on equipment in order to maintain top efficiency in performance, to minimize unwanted interruptions in service, and to eliminate major break-downs. To understand what is meant by preventive maintenance, it is necessary to distinguish between preventive maintenance and trouble locating and repair. The primary function of preventive maintenance is to *prevent* break-downs and the need for repair. On the other hand, the primary function of trouble locating and repair is to locate and correct *existing* defects. The importance of preventive maintenance cannot be overemphasized. The usefulness of the entire system of communication depends upon the equipment being ready to operate at peak efficiency when needed.

Note. The operations in this section of the manual are first and second echelon (organization operators and repairmen) maintenance. Some operations in section XI, moistureproofing and fungiproofing, are higher echelon maintenance.

27. Description of Preventive Maintenance Techniques

a. General. Most of the electrical parts used in Repeater Set TC-19 require routine preventive maintenance. Those requiring maintenance differ in the amount and kind required. Because maintenance techniques cannot be applied indiscriminately, definite and specific instructions are needed. This section of the manual contains this type of specific instructions and serves as a guide for personnel assigned to perform the six basic maintenance operations: namely, FEEL, INSPECT, TIGHTEN, CLEAN, ADJUST, and LUBRICATE. Throughout this manual the lettering system for the six operations will be as follows:

F—Feel
I—Inspect
T—Tighten
C—Clean
A—Adjust
L—Lubricate *

The first two operations establish the need for the other four. The selection of operations is based on a general knowledge of field requirements. For example, the dust encountered on dirt roads during cross-country travel filters into the equipment no matter how much care is taken to prevent it. Rapid changes in climatic conditions (such as heavy rains followed by blistering heat) or excessive dampness, snow, and ice, tend to cause deterioration of exposed surfaces and parts.

b. Feel (F). The feel operation is used to determine if electrical connections, transformers, filters, etc., are overheated. Feeling indicates the existence of some types of defects requiring correction. The maintenance man must become familiar with the normal operating temperatures of transformers, etc., in order to recognize signs of overheating.

Note. It is important that the feel operation be performed as soon as possible after the shut-down, and always before any other maintenance is done.

c. Inspect (I). (1) *General.* Inspection is probably the most important of all of the preventive maintenance operations. If more than one man is available to do this work, choose the most observant, for careful observation is required to detect defects in the functioning of moving parts and other abnormal conditions. To carry out the inspection operation most effectively, make every effort to become familiar with the normal operating conditions and to be able to recognize and identify abnormal conditions readily.

(2) *Inspection.* Inspection consists of carefully observing all parts of the equipment, noticing their color, placement, cleanliness, etc. Inspect for the following conditions:

(*a*) Overheating, as indicated by discoloration, blistering, or bulging of the part or surface of the container, leakage of insulating compounds, and oxidation of metal contact surfaces.

(*b*) Placement, by observing that all leads and cabling are in their original positions.

* The Lubricate operation is inapplicable to Repeater Set TC-19.

(*c*) Cleanliness, by carefully examining all recesses in the units for accumulated dust, especially between connecting terminals. Parts, insulators, connections, joints, and wiring should be free of dust, corrosion, and other foreign matter. In tropical and high-humidity locations, look for fungus growth and mildew.

(*d*) Tightness, by testing any connections or mountings which appear to be loose, by slightly pulling on the wire, or by feeling the lug or terminal screw.

d. TIGHTEN (T). Any movement of the equipment caused by transportation, by concussion from falling shells, or by vibration from moving machinery, may result in loose connections which are likely to impair the operation of the repeater. The importance of firm mountings and connections cannot be over-emphasized; however, never tighten screws, bolts, and nuts unless it is known definitely that they are loose. Fittings that are tightened beyond the pressure for which they are designed will be damaged or broken. When tightening always be certain to use the correct tool of the proper size.

e. CLEAN (C). When the schedule calls for a cleaning operation, it does not mean that every item which bears that identifying letter must be cleaned each time it is inspected. Clean parts only when inspection shows that it is necessary. The cleaning operation to be performed on each part is described in the paragraph pertaining to that item.

Note. Gasoline will not be used as a cleaning fluid for any purpose. Solvent, dry cleaning, is available as a cleaning fluid through established supply channels.

f. ADJUST (A). Adjustments are made only when necessary to restore normal operating conditions. Specific types of adjustments are described in the paragraph pertaining to the particular item.

28. Repeater TG-31, Exterior

a. INSPECT (I). Carefully examine the case and front panel of the repeater for broken or damaged places, chipped paint, dirt, rust, dust, corrosion, and loose or missing screws. Carefully inspect the corners and small crevices for dirt, dust, and lint.

b. TIGHTEN (T). Tighten all loose screws in the repeater with a suitable screwdriver. Pay particular attention to the screws in the front panel and the four mounting screws which hold the repeater in the case. All screws should be tightened snugly, but not forced.

c. CLEAN (C). With a soft, dry cloth, wipe off all dirt, dust, and lint on the repeater case and on the front panel. Do not use soap and water at any time.

29. Power Cord

a. INSPECT (I). Inspect the power cord for cracked or deteriorated insulation or frayed or cut insulation. A badly damaged cord may cause a short circuit on the power supply.

b. CLEAN (C). Remove grease, oil, and other foreign matter with dry-cleaning solvent (SD). Do not use soap and water at any time.

30. Fuses

a. INSPECT (I). Inspect the fuses for dirt, dust, and corrosion. Carefully examine the fuse holders for dirt, dust, or corrosion.

b. CLEAN (C). Clean the fuses with a soft bristle brush. Brush all dirt, dust, and foreign matter out of the fuse holders.

31. Headset

a. INSPECT (I). Inspect the headset for chipped places, dirt, dust, rust, and corrosion. Inspect the exterior only.

b. CLEAN (C). Clean the headset with a clean, dry cloth. Wipe off the exterior only. Do not attempt to clean any part of the interior of the headset.

32. Ground Rods

a. INSPECT (I). Inspect the ground rod for rust and corrosion.

b. TIGHTEN (T). Tighten the thumbscrew at the connection. Do not use pliers to tighten this thumbscrew.

33. Relays

a. GENERAL. In applying preventive maintenance to the polar relays it is essential that maintenance personnel familiarize themselves with all details of the relay by examining it while it is in good condition. In this way they will be prepared to recognize defects which will affect operation of the relay. Extreme care should be used when handling the relay so as not to damage or misalign the relay mechanism.

b. INSPECT (I). (1) A relay is considered to be in good operating condition if—

(*a*) The exterior is free from dirt and dust.

(*b*) The relay assembly is securely mounted.

(*c*) The relay coil shows no signs of overheating.

(*d*) The wire insulation is not frayed or torn.

(*e*) The connections to the relay are tight.

(*f*) The contacts are lined up and correctly spaced.

(*g*) The contact springs are in good condition.

(*h*) The armature travels freely and functions satisfactorily.

(*i*) The contacts are not burned, pitted, corroded, or eroded.

(2) A relay is considered *abnormal* if it fails to meet any of the nine requirements of a normal unit.

(3) Inspect to see if gas adsorber units are in place. If no gas adsorber units are present in the relay they should be installed immediately (par. 72). If gas adsorber units are present they should be replaced if there is excessive corrosion of the relay contacts and a formation of black dust on the relay frame below the contacts.

c. TIGHTEN (T). Tighten all loose connections and mounting screws, but do not apply enough force to damage the screws or break the parts.

d. CLEAN (C). Invert the relay cover and tap it to loosen dirt, then wipe it with a clean, dry, lint-free cloth.

34. Meter

The meter is an extremely delicate instrument and must be handled very carefully. It requires very little maintenance. It is a precision instrument and cannot be repaired in the field. Under no circumstances will the meter unit be removed from its case in the field. A damaged meter should be replaced with a spare and returned to the depot for repair.

a. INSPECT (I). Inspect the leads and connections to the meter. Look for loose, dirty, and corroded connections. Look for cracked or broken cover glass. Since the movement of a meter is extremely delicate, its accuracy will be seriously affected if the glass is broken and dirt and water filter through.

b. TIGHTEN (T). Tighten all loose connections and screws. Inspect all loose meter wires for dirt or corrosion before they are tightened. The tightening of meter connections requires a special technique, because careless handling can easily crack the meter case. To prevent breakage, hold firmly the retaining nut which makes contact with the meter case while the outside nut is being tightened. This permits the tightening of the connections without increasing the pressure of the head of the stud against the inside of the meter case.

c. CLEAN (C). (1) Meter cases are made of hard, highly polished bakelite, and can usually be cleaned with a dry cloth. If cleaning is difficult, the cloth should be dampened with dry-cleaning solvent (SD). Clean dirty connections with a small, stiff brush dipped in dry-cleaning solvent (SD) or with a small piece of cloth dipped in solvent. Since solvents do not entirely remove dirt from hard surfaces, some of the dirt will be left in a softened state and must be removed with a clean cloth.

(2) Clean corroded connections by sanding them lightly with a very fine grade of sandpaper, such as No. 0000. After they are cleaned, wipe the connections carefully with a clean cloth.

d. ADJUST (A). Normally, meters should indicate 0 when the equipment is turned off. The procedure for setting a meter on 0 is not difficult and requires only a screwdriver. Before adjusting the meter, tap the meter case lightly with the tip of one finger. This will help the meter to overcome the slight friction which sometimes exists at the bearings and prevents an otherwise normal unit from coming to rest at 0. If adjustment is needed, insert the tip of the screwdriver in the slotted screw head located below the meter glass and slowly turn the adjusting screw until the pointer is at 0. View the meter face and pointer "full on" and not from either side. Avoid turning the screw too far, because the needle may be bent or the hairspring damaged.

35. Binding Posts

a. INSPECT (I). Inspect the binding posts on the repeater for dirt, dust, rust, and corrosion. Carefully examine for loose binding posts.

b. TIGHTEN (T). Tighten any loose binding posts. Do not exert too much force or the binding posts may be damaged.

c. CLEAN (C). Clean the binding posts with a soft bristle brush.

36. Protectors

a. INSPECT (I). Inspect the protectors to make sure that the carbon blocks are smooth and not pitted and that the assembly is free from dust and dirt. An inspection is recommended after every lightning storm in the area.

b. CLEAN (C). Wipe the carbon block and the porcelain block including the carbon insert with a dry, lint-free cloth. Discard any cracked or pitted blocks and any which cannot be wiped smooth. Do not rub blocks together, and do not use a file, knife, or abrasive.

37. Telegraph Key

a. INSPECT (I). Inspect the telegraph key for proper operation and for dirt, dust, and corrosion.

b. TIGHTEN (T). Tighten all loose connections on the telegraph key.

c. CLEAN (C). Clean the telegraph key with a soft bristle brush. Use the brush dipped in dry-cleaning solvent to remove excessive foreign matter.

d. ADJUST (A). Adjust the key for proper operation (par. 18*c*).

38. Wiring

a. GENERAL. The preventive maintenance procedure for wiring is intended for all connections used on Repeater TG-31. The term wiring as used in preventive maintenance is intended to include all wiring and cabling placed at the factory. The wiring can be regarded as the life lines of the equipment. The condition of the wiring must be closely observed. Equipment operated under all kinds of weather conditions and moved on all kinds of roads subjects wiring to a great deal of punishment.

b. INSPECT (I). (1) Inspect the wiring for cracked or deteriorated insulation, frayed or cut insulation at the connecting and supporting points, and improper placement which places the wiring or connections under strain. Watch for kinks and improper supports.

(2) Several ground connections are used in the wiring system. These should be kept clean and tight. If any one of the grounded points is open, it may interfere with the operation of the equipment.

(3) If the frame of the equipment is grounded at a loose point, the loose connection nullifies protection for the operating personnel.

c. TIGHTEN (T). Tighten loose fasteners, cable clamps, coupling rings, wiring connections, etc.

39. Keys and Switches

a. INSPECT (I). (1) Inspect the mechanical action of each key or switch and look for signs of dirt or corrosion on all exposed elements. In some cases, examine the elements of the key or switch visually; in others, examine the action of the key or switch by flipping the control knob or toggle, or by pressing the switch button and noting the freedom of movement and the amount of spring tension.

(2) Press the button (MEAS VOLTS key) or turn the knobs (CUT LINE keys) and observe the action of the key elements. The springs should have ample tension. The key action should be free. The contacts should be clean. Brown or black stain on a silver-plated contact should not be confused with dirt or corrosion. It is silver oxide and is a satisfactory conductor. The wiping action of the contacts usually removes the silver oxide at the point of contact.

b. CLEAN (C). Clean corroded surfaces and contacts with crocus cloth (Signal Corps stock No. 6Z2000). Clean all dirty contacts with a cloth or brush dipped in carbon tetrachloride. After cleaning, polish the contacts with a dry cloth.

40. Potentiometer

a. INSPECT (I). (1) Inspect the mechanical condition of the ADJ TONE potentiometer. The shaft should turn easily in the bushing which supports it.

(2) Inspect the assembly and mounting, setscrews holding the knob, and the mounting nut.

(3) Inspect all parts of the potentiometer for cracks, dust, dirt, and corrosion.

b. TIGHTEN (T). Tighten the mounting nut or setscrews if they are loose. To tighten the mounting nut it is necessary to remove the knob. Loosen the setscrews and remove the knob. Tighten the mounting nut and replace the knob. Be sure the body of the potentiometer does not turn while the mounting nut is being tightened.

c. CLEAN (C). Clean the body of the potentiometer and the connections whenever they are dirty. Remove grease and dirt from the potentiometer parts with dry-cleaning solvent (SD), if necessary. Otherwise, clean with a brush or cloth.

41. Jacks

Jacks require very little attention, and only at infrequent intervals. Occasionally it will be necessary to tighten the mounting nut, clean the contacts, or increase the spiring tension. Remove dirt from the springs with a brush and dry-cleaning solvent (SD), and remove corrosion from the springs with

a piece of crocus cloth. Clean the contacts by drawing a clean burnishing blade back and forth between them several times. Do not use a nail file or an automotive contact burnisher. Increase spring tension, when necessary, by adjusting the spring near its point of attachment with a spring bender. Twist the bender slightly in the direction in which tension is desired and move it continuously along the slight bow in the spring. The action of the jack should be tried after each adjustment. Be careful to keep all soldered connections intact.

42. Plug

a. INSPECT (I). Inspect the headset plug for dirt, rust, and corrosion.

b. CLEAN (C). Use polish, metal paste, Signal Corps stock No. 6G1516 for cleaning and polishing telephone-type plugs. If plug is too badly corroded to be cleaned with the above-mentioned polish, use crocus cloth.

43. Capacitors

a. GENERAL. Before maintenance work is begun, it is absolutely necessary for the safety of personnel to *short-circuit all high-voltage capacitors* with a well-insulated screwdriver.

b. INSPECT (I). (1) Inspect the terminals of the capacitors for corrosion and loose connections. The mountings should be carefully inspected for any loose mounting screws, studs, or brackets. Examine the leads for poor insulation, for cracks, and for evidence of dry rot. Cut away frayed strands on the insulation. If the wire is exposed, wrap it with friction tape. The terminals of the capacitors should not be cracked or broken.

(2) The case of each capacitor must be thoroughly inspected for breaks, bulges, and discoloration. Whenever a defective capacitor is found, it should be removed and replaced if a replacement is available.

c. TIGHTEN (T). Tighten loose terminals, mountings, and connections on the capacitors.

d. CLEAN (C). Clean the case of the capacitor, the insulating bushings, and any connections that are dirty and corroded. The capacitor cases and bushings can usually be cleaned with a dry cloth, but if the deposit of dirt is difficult to remove, moisten the cloth with dry-cleaning solvent (SD).

44. Resistors

a. INSPECT (I). Examine the bodies of all types of resistors for blistering, discoloration, and other indications of overheating. Inspect leads, clips, and all other connections for corrosion, dirt, dust, looseness, and broken strands in the connecting wires. Check the security of all mountings. Do not attempt to move resistors with pigtail connections because there is danger of breaking the connections at the point where they enter the body of the resistor. Such defects cannot be repaired.

b. TIGHTEN (T). Tighten resistor connections and mountings whenever they are loose. If a resistor is allowed to remain loose, vibration may break the connection or damage the body.

c. CLEAN (C). (1) Clean all dirty or corroded connections on the resistors, using a cloth or brush dipped in dry-cleaning solvent (SD). If the resistor leads are corroded, it may be necessary to sand them lightly with a fine grade of sandpaper and then wipe them clean with a dry cloth.

(2) Resistors with discolored bodies cannot be cleaned. Discoloration is indicative of overloading at some time prior to the inspection and is probably due to circuit trouble, which requires analysis.

45. Transformers and Filters

Almost without exception, transformers and filters must be replaced if defective, but preventive maintenance techniques give some amount of protection against failure at inopportune times.

a. FEEL (F). Feel wax-impregnated transformers for signs of overheating. The surest sign of overheating is the presence of insulating compound on the outside of the seams of the case. Overheating is an indication of circuit trouble and requires a system analysis.

b. INSPECT (I). Inspect transformers and filters for general cleanliness, and for tightness of connections, connecting lugs or terminals, mounting brackets, and rivets.

c. TIGHTEN (T). (1) Tighten loose mounting screws or connections *immediately*.

(2) If it is necessary to remove wires to tighten loose parts, note the position of the wires before they are unsoldered and restore them to their original position.

d. CLEAN (C). (1) Clean the cases of the transformers and filters with a dry cloth. In a few instances it may be desirable to use dry-cleaning solvent (SD) to remove foreign matter.

(2) Corroded contacts or connections can be sandpapered and wiped clean.

(3) Clean corrosion from ground connections and from resoldered connections.

46. Preventive Maintenance Tools and Materials

a. The following tools (components of Tool Equipment TE-49) and materials will be needed in performing preventive maintenance:

Screw driver TL-21.
Screw driver TL-44.
Soldering iron TL-117.
Knife TL-29
Pliers TL-126.
Wrench TL-111.
Wrench set (socket wrenches).
Tool, sb, WECo No. 63 (socket wrench, triple end).
Tool, sb, WECo No. KS-2348 (small screw driver).
Tool, sb, WECo No. 265c (contact burnisher).
Tool, sb, WECo No. 417A (end wrench, 3/8 inch).
Tool, sb, WECo No. 259 (spring bender).
Soft bristle brush.
No. 0000 sandpaper.
Polish, metal paste, Federal spec No. P-P-556, type No. 111.
Crocus cloth.
Clean cloth.
Carbon tetrachloride.
Solvent, dry cleaning.

b. Make sure that all tools and materials required are on hand before starting preventive maintenance.

Section IX. PREVENTIVE MAINTENANCE CHECK LIST

47. Preventive Maintenance Check List

The following check list is a summary of the preventive maintenance to be performed on Repeater Set TC-19. The echelon column indicates which operations are first echelon maintenance and which operations are second echelon maintenance. Operations are indicated by the letters of the word FITCAL. For example, if the letters ITCA appear in the Operations column, the item to be treated must be inspected (I), tightened (T), cleaned (C), and adjusted (A).

48. Preventive Maintenance Check List for Repeater Set TC-19

Item No.	Operations	Item	When performed				Echelon
			Daily	Weekly	Monthly	Semi-annually	
1	ITC	Repeater, exterior (par. 28)	X				1st
2	IC	Power cord (par. 29)		X			1st
3	IC	Fuses (par. 30)		X			1st
4	IC	Headset (par. 31)		X			1st
5	IT	Ground rods (par. 32)		X			1st
6	I	Relays (par. 33)		X			2d
7	A	Meter (par. 34)		X			2d
8	ITC	Binding posts (par. 35)			X		1st
9	IC	Protectors (par. 36)			X		1st
10	ITCA	Telegraph key (par. 37)			X		1st

F Feel — I Inspect — T Tighten — C Clean — A Adjust — L Lubricate*

* The Lubricate operation is inapplicable to Repeater Set TC-19.

Item No.	Operations	Item	When performed				Echelon
			Daily	Weekly	Monthly	Semi-annually	
11	IT	Wiring (par. 38)			X		2d
12	TC	Relays (par. 33)			X		2d
13	IC	Keys and switches (par. 39)			X		2d
14	ITC	Potentiometer (par. 40)			X		2d
15	ITC	Meter (par. 34)			X		2d
16	ITC	Jacks (par. 41)			X		2d
17	IC	Plug (par. 42)			X		1st
18	ITC	Capacitors (par. 43)			X		2d
19	ITC	Resistors (par. 44)			X		2d
20	FITC	Transformers and filters (par. 45)			X		2d
21	ICA	Jacks (par. 41)				X	2d

F Feel — I Inspect — T Tighten — C Clean — A Adjust — L Lubricate*

* The Lubricate operation is inapplicable to Repeater Set TC–19.

Section X. LUBRICATION

Note. A War Department Lubrication Order is not issued on Repeater Set TC-19 (Intermediate, Telegraph) since it requires no lubrication.

Section XI. MOISTUREPROOFING AND FUNGIPROOFING

49. General

When operated in tropical areas where temperature and relative humidity are extremely high, Signal Corps equipment requires special attention. These are some of the problems met:

a. Resistors, capacitors, coils, chokes, transformer windings, etc., fail because of the effects of fungus growth and excessive moisture.

b. Electrolytic action, often visible in the form of corrosion, takes place in resistors, coils, chokes, transformer windings, etc., causing eventual breakdown.

c. Hook-up wire insulation and cable insulation break down. Fungus growth accelerates deterioration.

d. Moisture forms electrical leakage paths on terminal boards and insulating strips causing flashovers and crosstalk.

50. Treatment

A moistureproofing and fungiproofing treatment has been devised which, if properly applied, provides a reasonable degree of protection against fungus growth, insects, corrosion, salt spray, and moisture. The treatment involves the use of a moisture- and fungi-resistant varnish applied with a spray gun or brush. Refer to TB SIG 13, Moistureproofing and Fungiproofing Signal Corps Equipment, for a detailed description of the varnish-spray method of moistureproofing and fungiproofing and the supplies and equipment required in this treatment.

Caution: Varnish spray may have toxic effects if inhaled. To avoid inhaling spray, use respirator if available; otherwise, fasten cheesecloth or other cloth material over nose and mouth. Never spray varnish or lacquer near an open flame. Do not smoke in a room where varnish or lacquer is being sprayed. The spray may be highly explosive.

51. Repeater TG-31 (Intermediate, Telegraph)

a. PREPARATION. Make all repairs and adjustments necessary for proper operation of the equipment.

b. DISASSEMBLY. (1) With the carrying case open, remove the four large roundhead screws which hold the repeater in the carrying case, and lift out the repeater.

(2) Place the repeater in an upside-down position, supporting it on the handles. Loosen four fasteners (slotted head) and remove the cover which conceals the wiring to the relay mountings and resistors.

(3) Place the repeater in its upright position. Loosen the fasteners (slotted head) holding the meter panel. Open the panel ((1), fig. 15) and tie so that it will stay open.

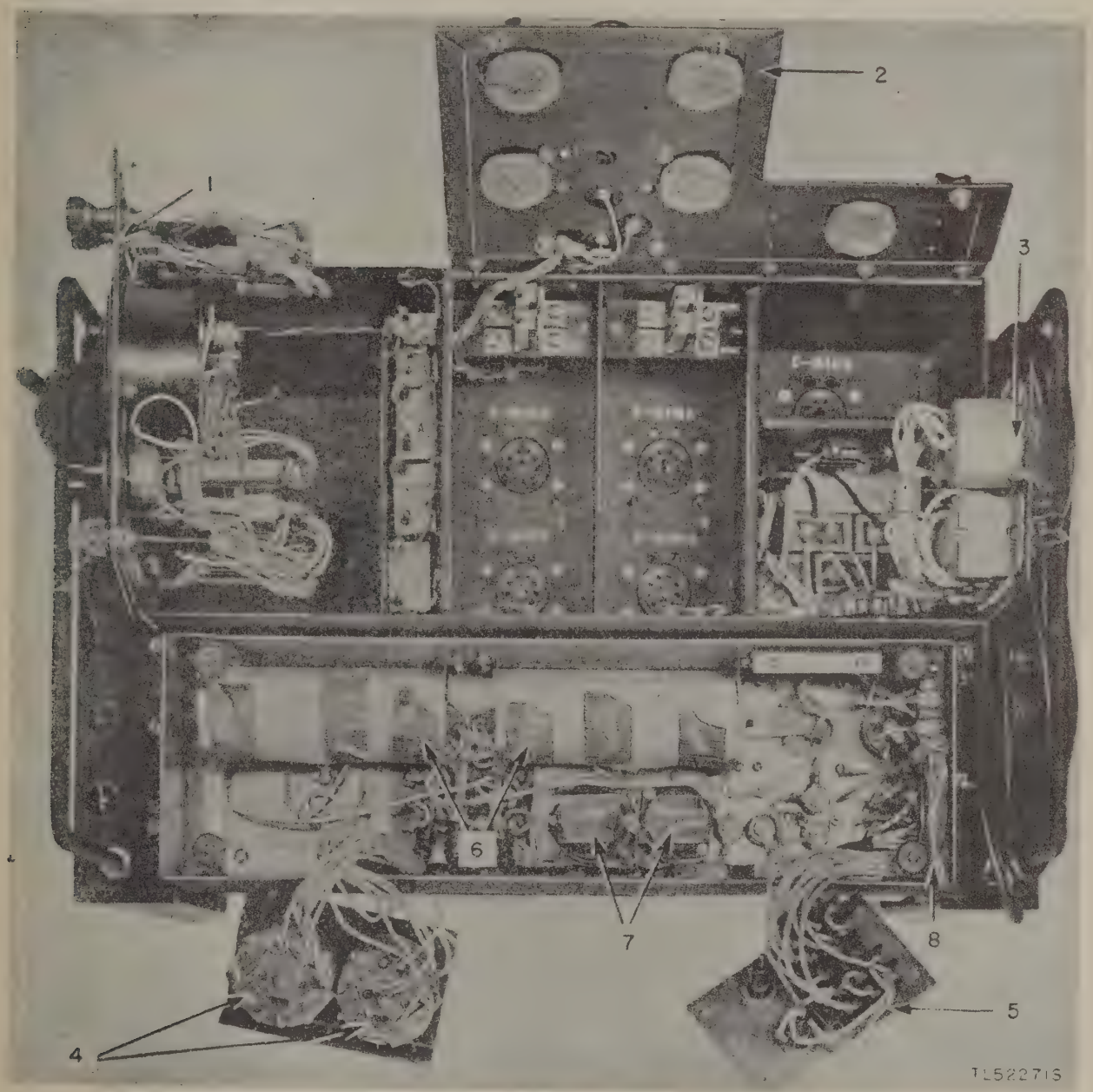


Figure 15. Top view of Repeater TG-31 (Intermediate, Telegraph) prepared for moistureproofing and fungiproofing treatment.

(4) Loosen the three relay-compartment fasteners (winghead), open the cover ((2), fig. 15) and remove the five polar relays. These relays are not to be treated.

(5) Loosen the fastener (slotted head) which secures the panel on which the repeater unit power switch is mounted. Open the panel ((3), fig. 15) and tie so that it will stay open.

(6) Loosen the four knurled fasteners holding the rectifier unit cover, and remove the cover.

(7) Remove the two vibrators.

(8) Remove the four screws holding the panel on which the two ADJUST VOLTS switches are mounted, and place the panel in a position so that the wiring underneath is accessible ((4), fig. 15).

(9) Remove the four screws holding the panel on which the two toggle switches are mounted, and place the panel in position so that the wiring underneath is accessible ((5), fig. 15).

c. Cleaning. Clean all dirt, dust, rust, and fungus from the equipment to be processed. Clean all oil and grease from the surfaces to be varnished.

d. Masking. (1) Mask the two selenium rectifier stacks in the rectifier compartment ((6), fig. 15).

(2) Mask the two selenium rectifier stacks on the under side of the chassis ((1), fig. 16).

(3) Masking may be placed on the ADJUST VOLTS switches ((4), fig. 15), the sockets for the frequency generators ((7), fig. 15), and fuse C and spare ((8), fig. 15) as a precautionary measure to avoid getting any of the lacquer on any of the contacts.

e. Drying. Place equipment in oven or under heat lamps and dry for 2 or 3 hours at 160° F.

Caution: Do not exceed 160° F. Check temperature frequently and note appearances of waxes and insulating compounds on components. If wax or other insulating compound shows evidence of softening, reduce temperature and increase drying time 1 hour for each 10° F. drop in temperature.

f. Varnishing Upper Side of Chassis. Apply three coats of moistureproofing and fungiproofing varnish (Lacquer, Fungus-resistant, spec No. 71-2202 (stock No. 6G1005.3), or equal). Allow each coat to air-dry for 15 to 20 minutes before applying the next coat. The lacquer should be applied immediately after equipment is removed from oven. If this is not accomplished immediately, moisture

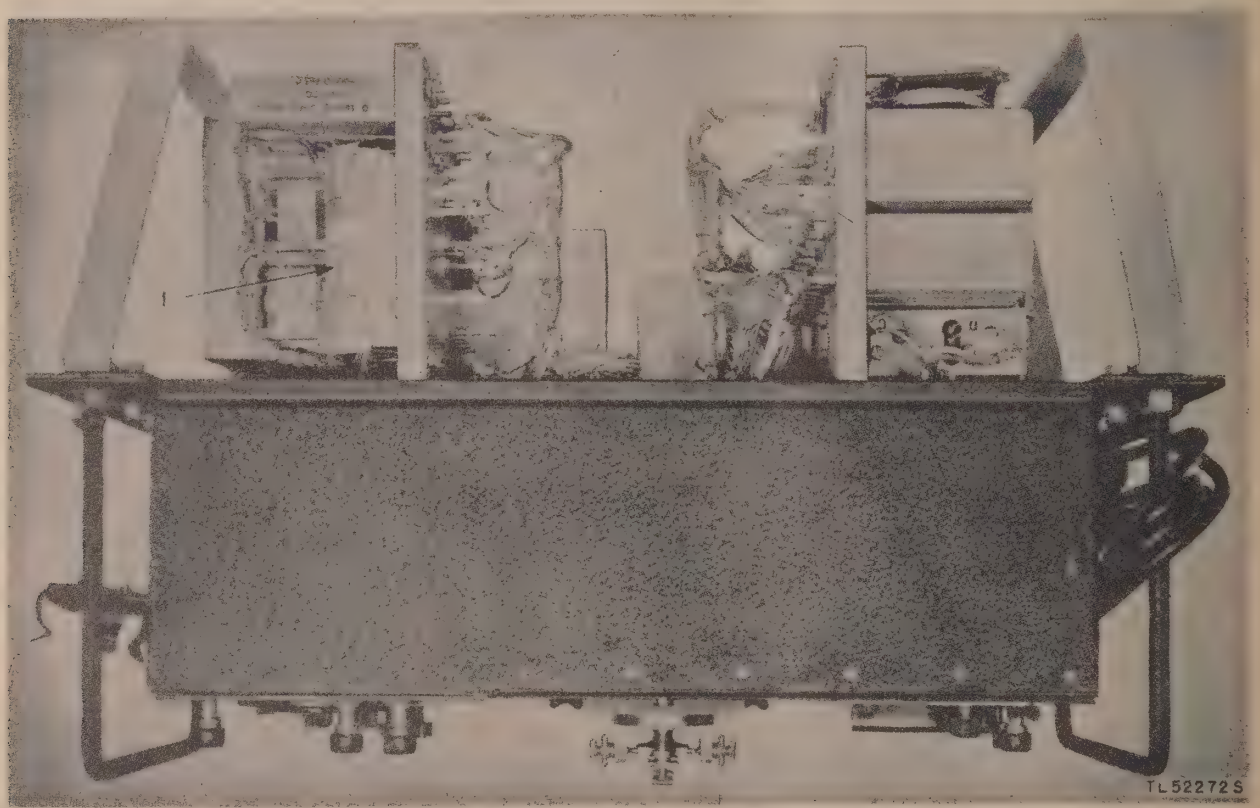


Figure 16. Side view of Repeater TG-31 (Intermediate, Telegraph) prepared for moistureproofing and fungiproofing treatment.

will condense on equipment, thereby causing lacquer to dry over the moisture and peel off readily. The lacquer should be applied by brush to the following locations:

(1) Wiring and soldered connections above and below top panels, including rectifier unit.

(2) Edges of phenolic base of telegraph key, edges of phenolic blocks on which jacks are mounted, and edges of fuse mounting panel.

(3) The following parts of the meter:

(*a*) Between the glass and meter case.

(*b*) Between the zero adjusting screw and glass.

(*c*) At points where the terminals enter the back of the case.

(*d*) Seam between the back and side of the case.

g. Varnishing Under Side of Chassis. (1) Close and fasten top panel covers and place repeater in an upside-down position.

(2) Apply brush coat to wiring and soldered connections on the under side of the chassis.

Caution: Polar type relays shall not be treated with a moistureproofing and fungiproofing lacquer or varnish. Care also should be taken to prevent varnish getting into any of the switches, disks of the selenium rectifier stacks, and the sockets into which the polar relays and vibrators are mounted.

h. Reassembly. (1) Remove all masking tape, being careful not to peel varnish from nearby areas.

(2) Install or replace gas adsorber units in each polar relay. Replace the relays only after the equipment is absolutely dry.

(3) Reassemble the repeater in reverse order of disassembly instructions and test its operation.

i. Marking. Mark the letters MFP and the date of treatment near the nameplate.

Example: MFP—8 Jun 44.

52. Moistureproofing and Fungiproofing After Repairs

If, during repair, the coating of protective varnish has been punctured or broken, and if complete treatment is not needed to reseal the equipment, apply a brush coat to the affected part. Be sure the break is completely sealed.

PART FOUR

AUXILIARY EQUIPMENT

(Not Used)

PART FIVE

REPAIR INSTRUCTIONS

Section XII. GENERAL REPAIR PROCEDURE

53. Repair Techniques

a. General. A complete knowledge of the detailed functions of the various parts and circuits in the equipment and trouble-locating procedures is necessary to perform satisfactory repairs. Keep service failures to a minimum by careful handling of the equipment during installation and operation, and by being careful when making field repairs and adjustments. Do not disturb the wiring any more than is necessary in testing or inspecting. If a soldering iron is used, do not drop splashes of solder on apparatus parts or wiring terminals.

b. Wiring Diagrams. Figure 33 is a wiring diagram of the repeater circuit and figure 34 is a wiring diagram of the rectifier power circuit. In these diagrams, each piece of apparatus has a letter designation corresponding to that shown on the wiring side, that is, the terminal side of each piece of apparatus. The apparatus is shown as viewed from the wiring side. In these diagrams, each piece of apparatus is arbitrarily assigned a number, and lines called feed lines representing the individual wires are carried a short distance and terminated on a common or base line running at right angles to the feed lines. These feed lines are marked with the color of the wire and have a number near the base line which is the same as the number of the piece of apparatus to which the other end of the wire is connected. It is not necessary to trace a connection through the common or base line and no provision is made for doing so. By observing the color and identification number, it is possible to trace directly to the other end of the wire. For example, by reference to figure 33, the resistor E numbered 66 has connected to it a wire BR 76. This means a brown wire is connected to 76. Capacitor G which is numbered 76 likewise shows a brown wire BR 66. Therefore, these are the two ends of the same wire, one end connected to the resistor E and the other end connected to the capacitor G.

54. Unsatisfactory Equipment Reports

a. When trouble in equipment used by Army Ground Forces occurs more often than repair personnel feel is normal, WD AGO Form 468 (Unsatisfactory Equipment Report) should be filled out and forwarded through channels to the Office of the Chief Signal Officer, Washington 25, D. C.

b. When trouble in equipment used by Army Air Forces occurs more often than repair personnel feel is normal, AAF Form 54 should be filled out and forwarded to the Commanding General, Air Matériel Command, Wright Field, Dayton, Ohio, in accordance wtih AAF Regulation No. 15-54.

Section XIII. DETAILED FUNCTIONING OF EQUIPMENT

55. Theory of Operation

a. General. Telegraph repeaters using the polarential (type B) principle of transmission do not require service adjustments to compensate for variations in the electrical characteristics of the line due to changes in leakage resistance and grounded capacitance as a result of changing weather conditions.

b. Polarential Operation. Fundamentally, a circuit operating on a polarential basis uses polar transmission in one direction and differential transmission in the other direction. These two words have been combined to form the word polarential.

(1) *Polar transmission.* In a polar transmission system, the marking and spacing line currents are of the same magnitude but flow in opposite directions, and hence, the receiving relay operates on reversals of line current and requires no local bias circuit.

(2) *Differential transmission.* In a differential transmission system, the marking and spacing line currents are in the same direction, but are different in magnitude. This difference as applied to the polarential method of operation requires a spacing current about 2½ times the marking current. Since the spacing current is in the same direction as the marking current, a local bias circuit is required on the receiving relay of the receiving repeater. The effect of this local biasing circuit is to hold the receiving relay on marking until the spacing line current is of sufficient value to overcome the effect of the biasing circuit and operate the receiving relay

to space. By fixing this local biasing circuit in a marking direction at one-half the sum of the received marking and spacing line currents, and connecting the line winding of the receiving relay so that the line current tends to operate the relay to space, the net effect on the armature of the receiving relay is equivalent to polar transmission. To get this equivalent of polar transmission in both directions on one telegraph channel, the opposite ends of a polarential circuit are made dissimilar as regards the connections of the sending and receiving relay circuits and the operating voltages applied to the line. One end of the circuit applies negative and positive polarity of the same value while sending, and this is known as the *polar sending* end of the circuit. The other end of the circuit applies ground for marking and positive polarity for spacing and is known as the *differential sending* end of the circuit. The positive polarity at the differential sending end is approximately twice the value of the negative or positive polarity applied at the polar sending end.

(3) *Complete transmission system.* Figure 17 is a theoretical schematic diagram of a system with Repeater TG-31 and two repeaters such as Repeater TG-30. The operation from terminal A to terminal B will be considered. Since the SEND relay of terminal A applies a negative polarity to the line when sending a mark and a positive polarity of the same value when sending a space, it is said to be the polar sending end of the circuit. Consequently, relay A at the intermediate repeater is said to be

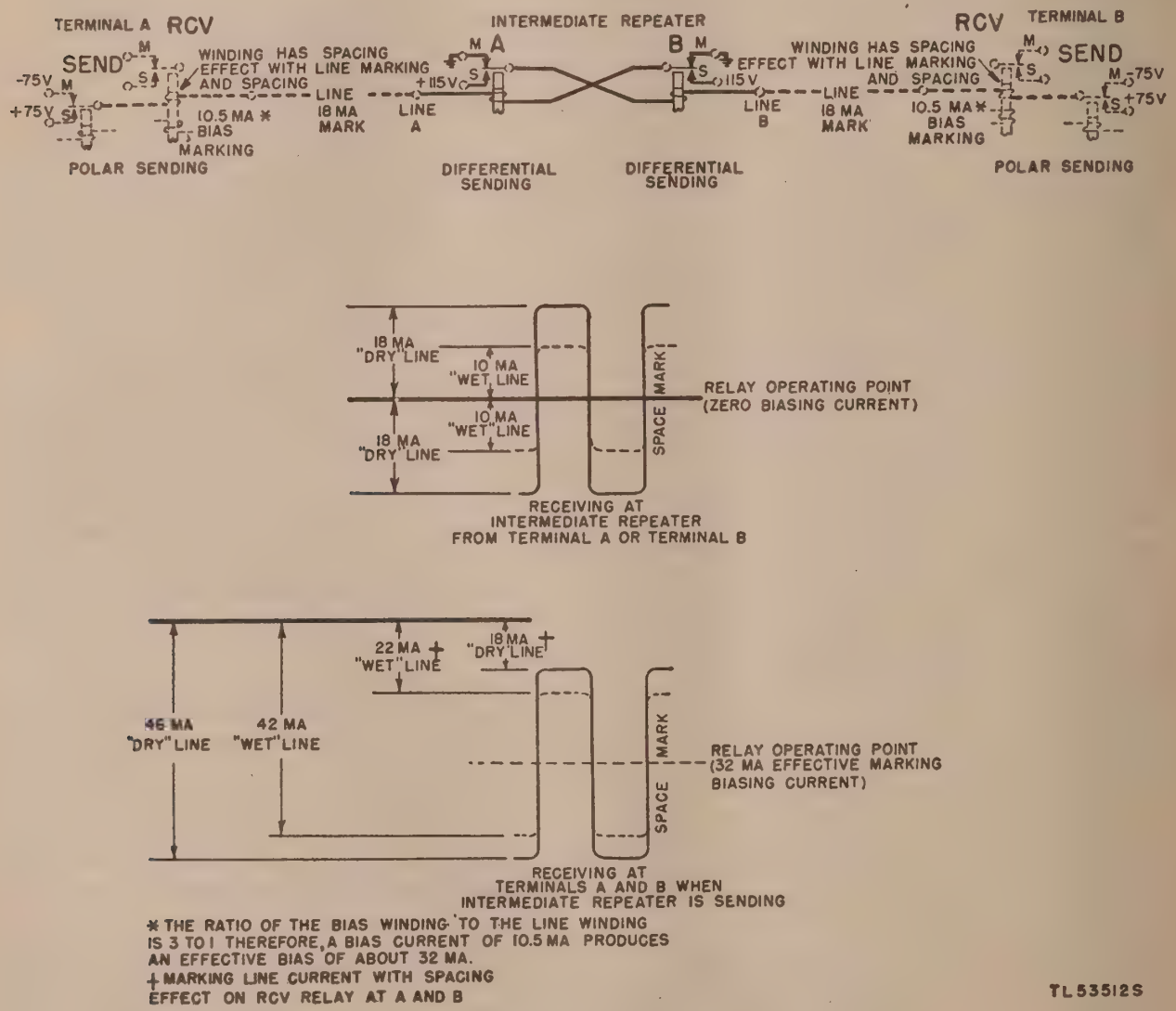

TERMINAL A
RCV
SEND
-75V
+75V
WINDING HAS SPACING EFFECT WITH LINE MARKING AND SPACING
10.5 MA * BIAS MARKING
POLAR SENDING
LINE
18 MA MARK
LINE A
INTERMEDIATE REPEATER
+115V
DIFFERENTIAL SENDING
LINE B
DIFFERENTIAL SENDING
RCV
TERMINAL B
SEND
+75V
POLAR SENDING
18 MA "DRY" LINE
10 MA "WET" LINE
MARK
SPACE
RELAY OPERATING POINT (ZERO BIASING CURRENT)
RECEIVING AT INTERMEDIATE REPEATER FROM TERMINAL A OR TERMINAL B
46 MA "DRY" LINE
42 MA "WET" LINE
22 MA + "WET" LINE
18 MA + "DRY" LINE
RELAY OPERATING POINT (32 MA EFFECTIVE MARKING BIASING CURRENT)
RECEIVING AT TERMINALS A AND B WHEN INTERMEDIATE REPEATER IS SENDING
* THE RATIO OF THE BIAS WINDING TO THE LINE WINDING IS 3 TO 1 THEREFORE, A BIAS CURRENT OF 10.5 MA PRODUCES AN EFFECTIVE BIAS OF ABOUT 32 MA.
+ MARKING LINE CURRENT WITH SPACING EFFECT ON RCV RELAY AT A AND B
TL 53512S

Figure 17. Theory schematic of polarential operation.

in the polar receiving end of the circuit with respect to terminal A. The telegraph signals are then repeated to line B by relay A which applies ground for marking and a positive polarity for spacing, and with respect to line B is the differential sending end of the circuit. Therefore, the RCV relay at terminal B is said to be in the differential receiving end of the circuit. Operation from terminal B to terminal A is similar to that just considered, with relay B at the intermediate repeater receiving the polar signals from terminal B and sending the differential signals to terminal A. Examples of the currents received at either end of the circuit under wet and dry line conditions are shown in figure 17. A study of these currents will show that the effect of line leakage in wet weather is minimized in both directions of transmission.

56. Repeater Circuit Line Operation

a. General. Figure 18 is a functional schematic diagram of the main repeating circuits. Refer to figure 19 for a schematic diagram of the main repeating circuits and monitoring circuit and to figure 31 for a detailed schematic circuit of the repeater. The PROT BLOCKS prevent damage to the equipment in case of line surges. Filter A reduces radiation to nearby radio-receiving equipment, and retard coil A and retard coil B are telephone noise-killer coils for simplex operation.

b. Main Repeating Circuits (fig. 18). Repeater TG-31 is a direct point through repeater; that is, the armature of relay A which receives from line A repeats directly to line B, and the armature of relay B which receives from line B repeats directly to line A. In the idle or marking condition, relays A and B are held marking by current through their respective line windings from terminal 3 to terminal 6. The current through these windings is produced by the power supplies at the distant terminal repeaters. The distant terminal repeater must be arranged so that the positive side of its power supply is grounded and the negative side applied to the line when a mark is being sent. The negative side of the power supply or the rectifier power circuit of Repeater TG-31 is grounded at the repeater power switch. When distant terminal A is sending a space, it applies the positive side of its power supply to the line. This results in current through the line winding of relay A of Repeater TG-31 from terminal 6 to terminal 3. Since this current is in the opposite direction from that for the marking condition, and since relay A has no local bias circuit, the armature of relay A operates to space. Current now flows from the positive side of the power supply of Repeater TG-31, through contact S of relay A, and over the line to distant terminal B. Under these conditions the power supply of Repeater TG-31 and the power supply of distant terminal B are in series, with the result that the current in line B increases from 18 milliamperes to 46 milliamperes on a dry line. This causes the receiving relay at terminal B to operate to space by overcoming the effect of the current in its bias winding. The receiving relay at terminal B repeats the spacing signal to its local equipment. Operation from terminal B to terminal A is similar

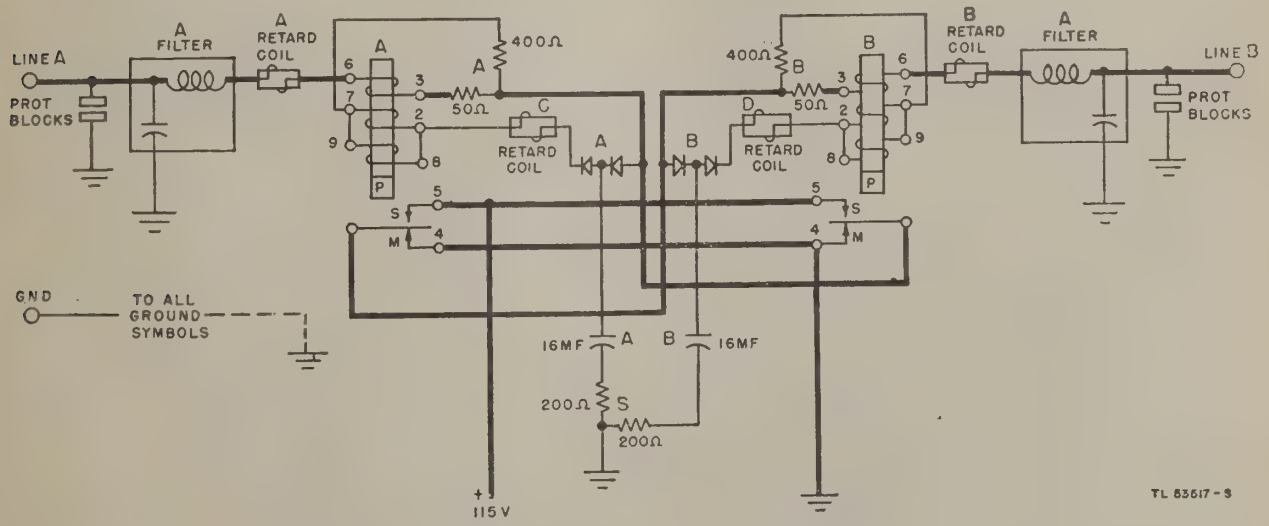


Figure 18. Schematic diagram, main repeating circuits.

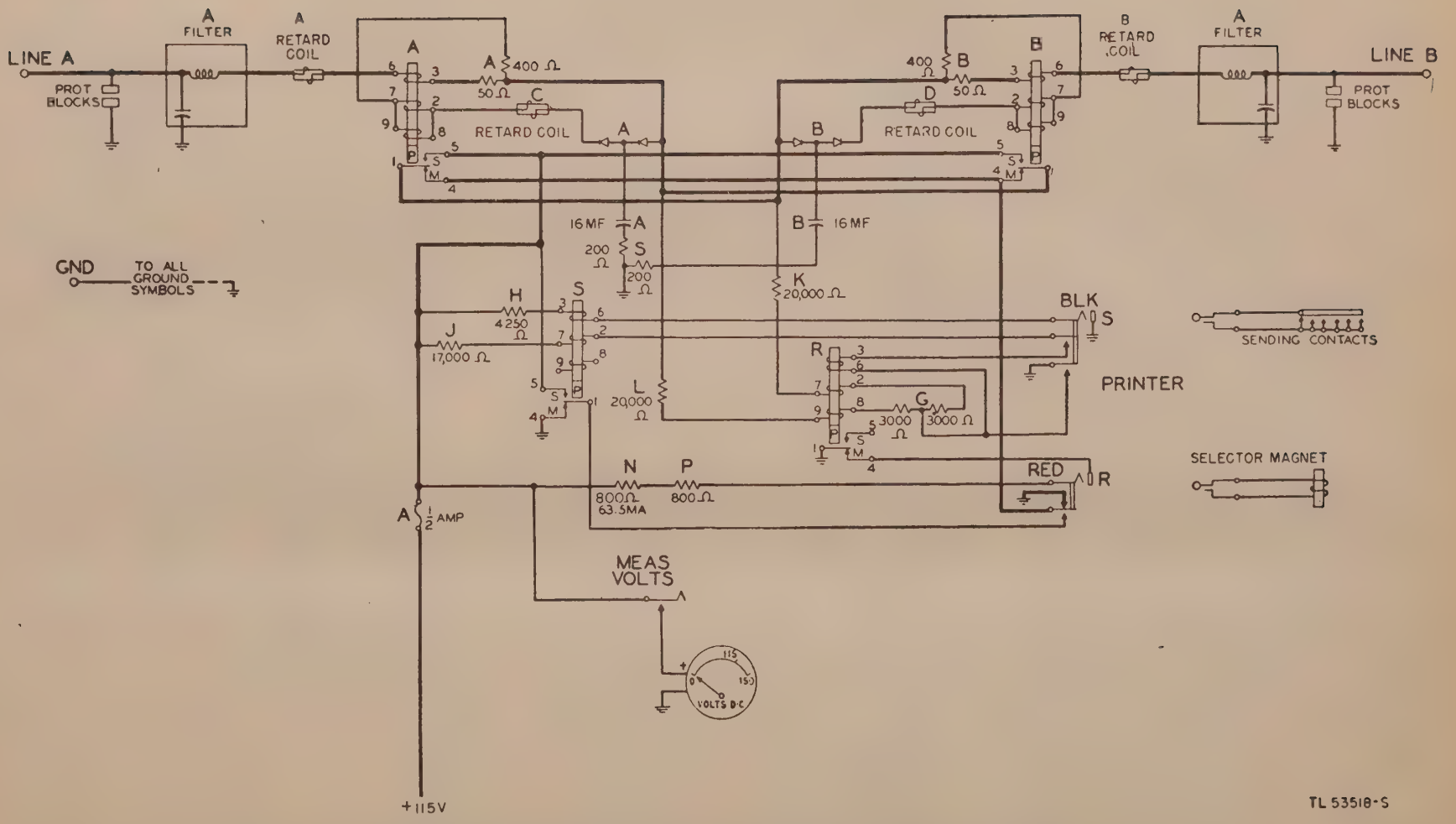


Figure 19. Schematic diagram, main repeating circuits and monitoring circuit.

to that discussed above with relay B repeating signals to line A.

c. Antikick-Off Circuits. Discharge of the line capacity, especially on wet field-wire circuits, tends to kick the receiving relay to spacing on outgoing signals. To prevent false operation during outgoing transmission, the receiving relay is held on marking by an antikick circuit. Varistor A in combination with capacitor A, resistor S (200 ohms), retardation coil C, resistor A, and windings 2-7 and 8-9 of relay A in parallel constitute an antikick circuit to hold relay A marking when relay B is receiving a spacing signal from line B and retransmitting it to line A. Likewise, varistor B, capacitor B, resistor S (200 ohms), retardation coil D, resistor B, and windings 2-7 and 8-9 of relay B in parallel hold relay B marking when relay A is receiving a spacing signal from line A and retransmitting to line B.

57. Monitoring Circuit

a. Figure 19 is a schematic diagram arranged to show the main repeating circuits and the monitoring circuit. Receiving relay R and sending relay S are associated with the teletypewriter monitoring circuit. When the teletypewriter sending and receiving cords are connected, the local circuits for relays R and S are completed by the contacts of PRINTER jacks R and S. There is no local current drain when these cords are not connected.

b. Relay R controls operation of the teletypewriter selector magnet both when receiving from the distant terminals and when copy is being sent locally. The selector magnet circuit is composed of ground at contact M of relay R, current-limiting resistors P and N, and positive 115 volts. The current in the selector magnet circuit is about 64 milliamperes. Winding 3-6 on relay R is a biasing winding tending to hold the relay operated to mark. When the distant terminal repeaters are sending mark signals there is no current in windings 8-9 and 2-7 of relay R, so that relay R is held operated to mark by the biasing current in windings 3-6. When one of the distant terminals sends a space, or a space is sent locally by opening the sending contacts of the monitoring teletypewriter, the current flows in windings 8-9 and 2-7 of relay R in such a direction and of sufficient value to operate relay R to space. Resistors K, L, and G limit the operating current in windings 8-9 and 2-7 of relay R to the proper value. Operation of relay R controls operation of the teletypewriter selector magnet circuit to produce local copy.

c. Relay S responds to opening and closing the sending contacts of the monitoring teletypewriter. It repeats the signals from the teletypewriter sending contacts to the distant terminals and to the teletypewriter selector magnet. This sending circuit consists of winding 3-6 of relay S and current-limiting resistor H connected to positive 115 volts. The bias circuit of relay S is connected spacing and consists of winding 2-7 and resistor J. When a space is sent by opening the sending contacts of the teletypewriter, winding 3-6 of relay S is opened and the relay is operated to space by the current in bias winding 2-7. This removes the ground being applied at contact M of relay S and applies positive 115 volts at contact S. Under these conditions the power supply of Repeater TG-31 and the power supply of each of the distant terminal repeaters are in series, with the result that the currents in line A and line B increase from 18 milliamperes to about 46 milliamperes. This causes the receiving relay at each of the distant terminal repeaters to operate to space by overcoming the effect of the current in their bias windings.

58. Manual Telegraph Set Circuit Operation

Figure 20 is a schematic diagram of the manual telegraph set which is a part of Repeater TG-31. The manuel telegraph set may be used when teletypewriter equipment is not available or cannot be used. The manuel telegraph circuit becomes operative when the headset is connected to the HEADSET jack and all teletypewriter cords are removed. The manual telegraph set circuit makes use of the repeater circuit with respect to the line receiving-relay functions. The telegraph key is a pole-changer type of key, that is, it applies ground for a marking signal and positive 115 volts for a spacing signal. These signals are applied to the line via the line windings of relay A and relay B in the same manner as relay A or B normally sends to the line. Operation of relay R, resulting from incoming line signals or operation of the telegraph key, produces a local signal (tone heard in headset). The tone is produced by an oscillator circuit consisting of a small neon lamp, TONE, capacitor P, resistor R, a 1-megohm potentiometer labeled ADJ TONE, and the headset or receiver. The freguency of the oscillator circuit is adjustable over a wide range by use of the ADJ TONE potentiometer (par. (2) 18*c*). In the idle or marking condition,

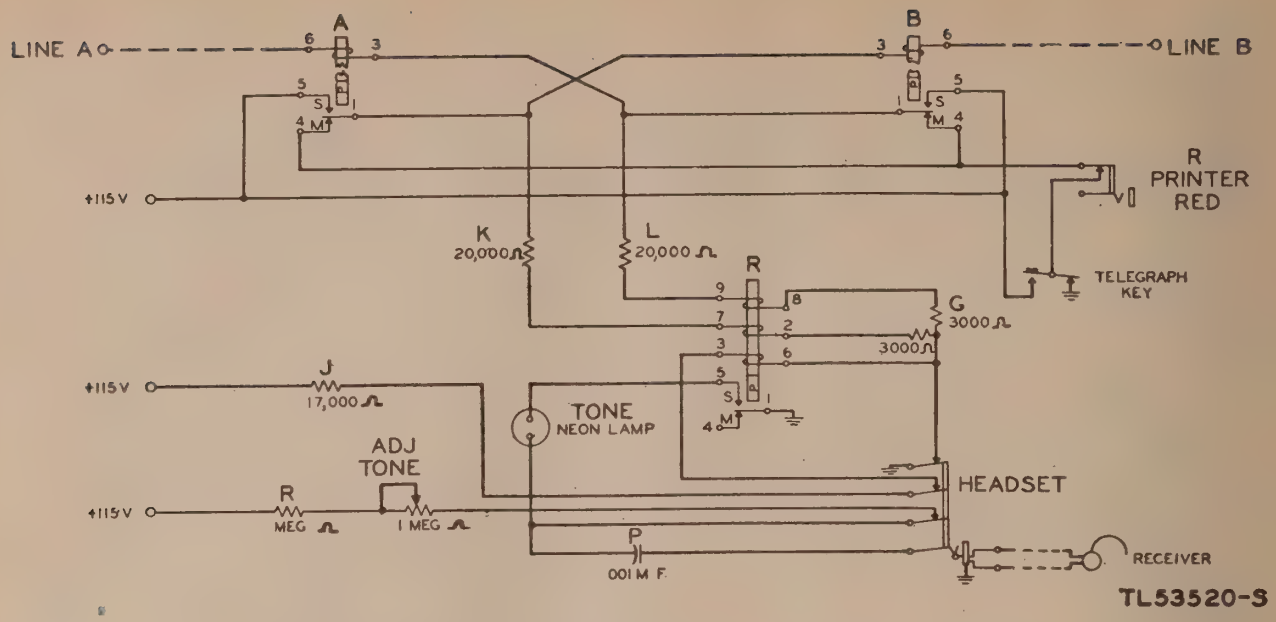


Figure 20. Schematic of manual telegraph set (part of Repeater TG-31).

the neon lamp (oscillator tube) does not function. Operation of relay R to space applies ground to the neon lamp via the space contact of relay R. The tube oscillates, thereby producing a tone in the headset.

59. Repeater Power Circuit Operation

a. General. The rectifier power circuit for Repeater TG-31 is shown schematically in figure 21 and in detail in figure 32. When the external power supply is 115-volt direct current the repeater-unit power switch is in the 115V DC position. When the external power supply is alternating current or a 12-volt storage battery, the repeater-unit power switch is in the 115V OR 230V AC OR 12V DC position. The negative side of the power supply or rectifier power curcuit is always grounded at the repeater-unit power switch. Operation of the rectifier power circuit for the various types of power supplies is covered in the following subparagraphs.

b. 115-Volt Direct Current. When the external power supply is 115-volt direct current supplied by either a gasoline-engine driven generator or dry batteries, the rectifier power curcuit is disconnected, and the repeater circuits receive the direct current which they require directly from the d-c supply connected to the power cord or the 115V DRY BAT binding posts. Power is also connected directly to the PRINTER POWER receptacle and a teletypewriter may be connected when the external power supply is furnished by a gasoline-engine driven generator.

c. 115-Volt Alternating Current. Figure 21 shows the rectifier power circuit arranged for 115-volt a-c operation. The repeater-unit power switch is operated to the 115V OR 230V AC OR 12V DC position, the right-hand toggle switch (12V STORAGE BAT—115V/230V AC) is operated to the 115V/230V AC position, and the left-hand toggle switch (115V AC—230V AC) is operated to the 115V AC position. With this switch arrangement, power is connected from the power cord, through the two toggle switches, to the primary of transformer T1. Windings 1-2 and 3-4 of transformer T1 are connected in parallel. The secondary of transformer T1 is provided with tap leads which are brought out to two ADJUST VOLTS rotary switches. This allows a tap to be selected which will give the required output voltage from the rectifier. Switch COARSE causes relatively large changes in output voltage and switch FINE causes small changes. The alternating current is rectified to direct current by the rectifying unit consisting of varistors H1 and H2. It is a selenium disk-type rectifying unit which provides full-wave rectification. Its output is filtered by retardation coil L1 and capacitors B1 and B2. The PRINTER POWER receptacle is in paralled with the 115-volt a-c supply.

d. 230-Volt Alternating Current. For a 230-volt a-c supply the left-hand toggle switch is operated to the 230V AC position. With this switch in this position, primary windings 1-2 and 3-4 of transformer T1 are connected in series. This results in the same output voltage from the secondary of transformer T1 as when the external power supply is 115-volt alternating current. Winding 1-2 of autotransformer T2 provides a 115-volt a-c supply for the teletypewriter motor when the external supply voltage is 230-volt alternating current.

e. 12-Volt Storage Battery. When a 12-volt storage battery is connected to the + and — 12V STORAGE BAT binding posts, the right-hand toggle switch is operated to the 12V STORAGE BAT position. The direct current supplied by the storage battery is converted to the equivalent of a 60-cycle supply by vibrator G and primary winding 5-6-7 of transformer T1. The midpoint of winding 5-6-7 is connected through retardation coil L2 to the negative battery polarity. The positive side of the battery supply is connected by the vibrator, first to one end of the transformer winding and then to the other end. Current flows for a short period of time from terminal 5 to terminal 6, and then for the same amount of time from terminal 7 to terminal 6. These currents are in opposite directions, and the design of vibrator G is such that the equivalent of a 60-cycle supply is obtained from the secondary winding of transformer T1. Capacitor E is in parallel with the vibrator. The function of retardation coil L2 and capacitor E is to improve the vibrator voltage wave at the output of transformers T1. Capacitor A, connected across the secondary taps of transformer T1, stores energy during the pulsing of the vibrator contacts and provides a voltage wave in the transformer windings similar to the wave obtained when operating from an a-c supply. This connection provides nearly the same output voltage when operating on alternating current or 12-volt storage battery and also results in minimum sparking at the vibrator contacts. Capacitor C connected across the battery terminals prevents any radio-

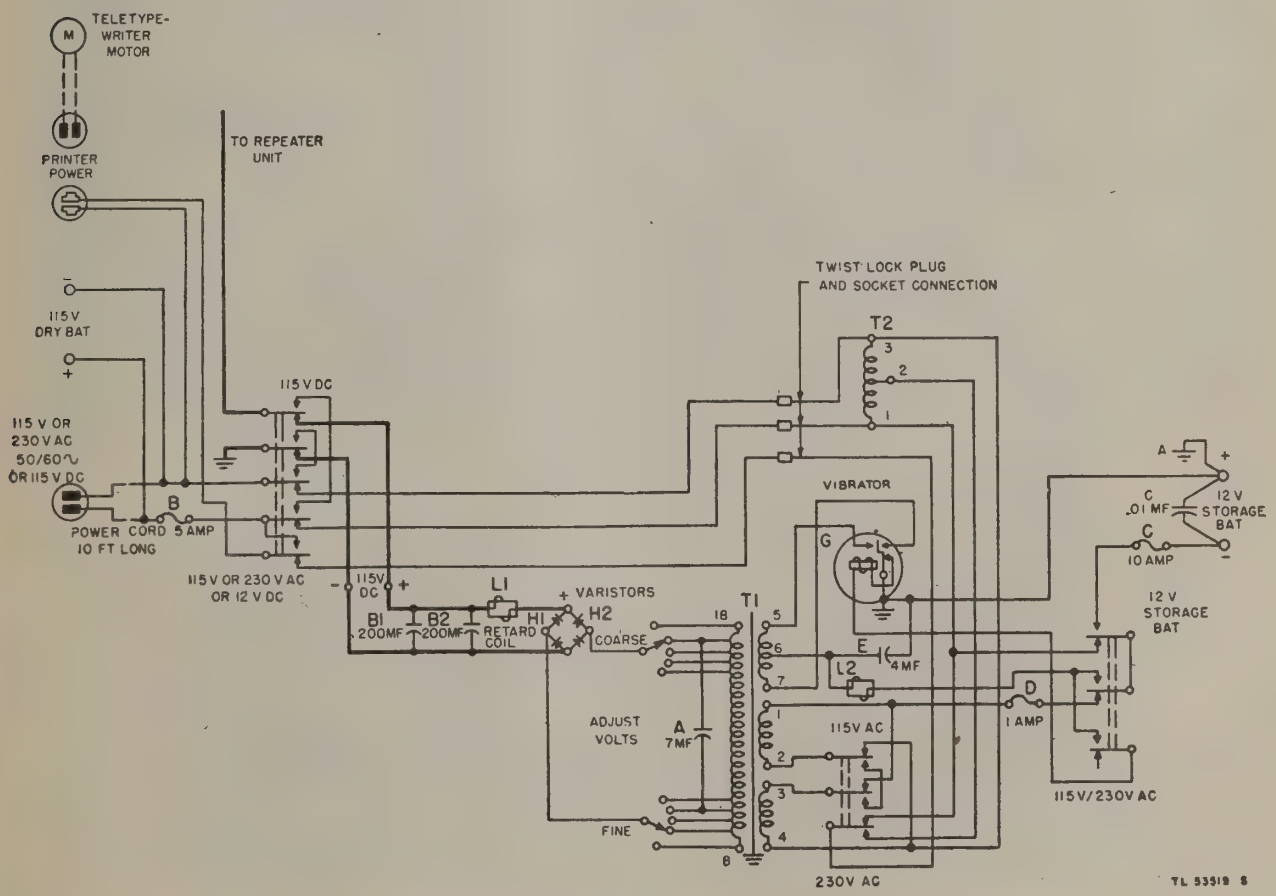


Figure 21. Schematic diagram, rectifier circuits.

frequency current from flowing out of the rectifier circuit over the battery input leads. The PRINTER POWER receptacle is not connected to the 12-volt storage battery.

Section XIV. TROUBLE LOCATION

60. General Trouble-Locating Information

No mater how well equipment is manufactured, faults will develop in service. When such faults occur, the repairman must locate and correct them as rapidly as possible. This section contains general information to aid personnel engaged in the important duty of trouble locating.

a. Trouble-Locating Data. Take advantage of the material contained in this manual to help in the rapid location of faults. Consult the following data when necessary.

(1) Complete schematic diagrams (figs. 31 and 32).

(2) Schematics of repeater circuits (figs. 18 to 21).

(3) Wiring of circuits, circuit label (figs. 33 and 34).

(4) Illustrations of Repeater TG-31 (figs. 4, 25, 26, and 27).

b. Trouble-Locating Steps. The first step in servicing a defective repeater is to sectionalize the fault. Sectionalization means tracing the fault to the component or circuit responsible for the trouble in the repeater. The second step is to localize the fault. Localization means tracing the fault to the defective part responsible for the trouble. Some faults such as burned-out resistors and shorted transformers can be located by sight and smell. The majority of faults, however, must be located by checking voltage and resistance.

61. Test Equipment

Two items of test equipment are needed for test and maintenance of Repeater TG-31.

a. Voltohmmeter. A voltohmmeter is required for measuring a-c or d-c voltages, the resistance of resistors, and to check capacitors for short circuits or grounds. For this purpose use Voltohmmeter I-166 or any other available voltohmmeter having the following characteristics: d-c voltage range, 0-15, 0-30, 0-150, and 0-300 volts; a-c voltage

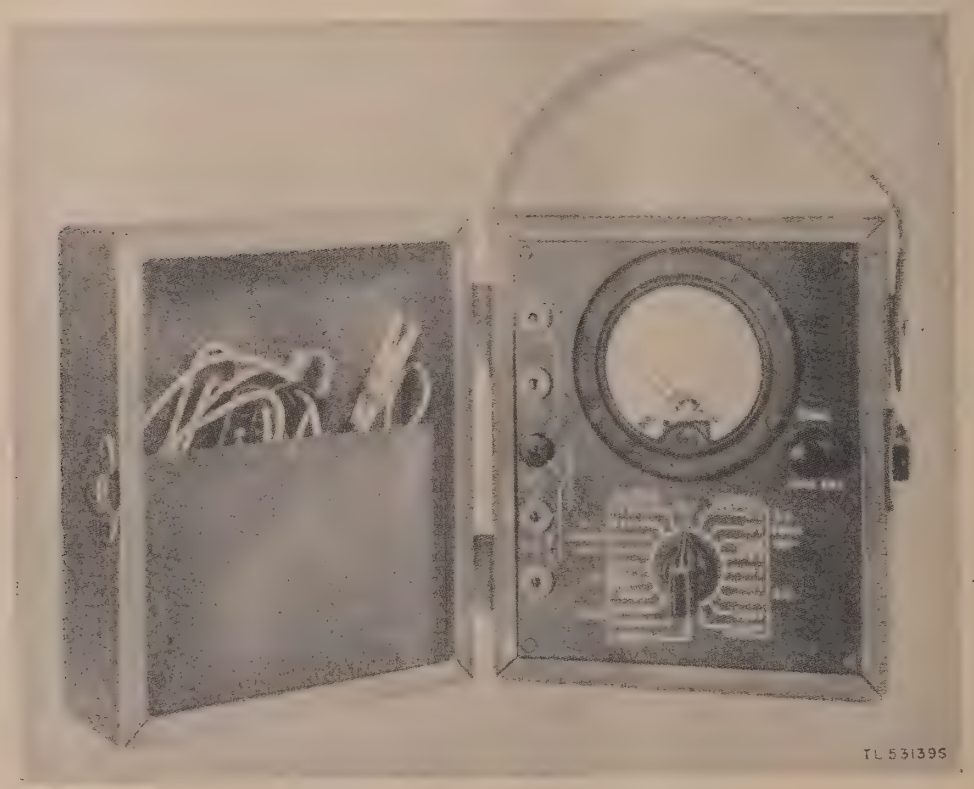


Figure 22. Voltohmmeter I-166.

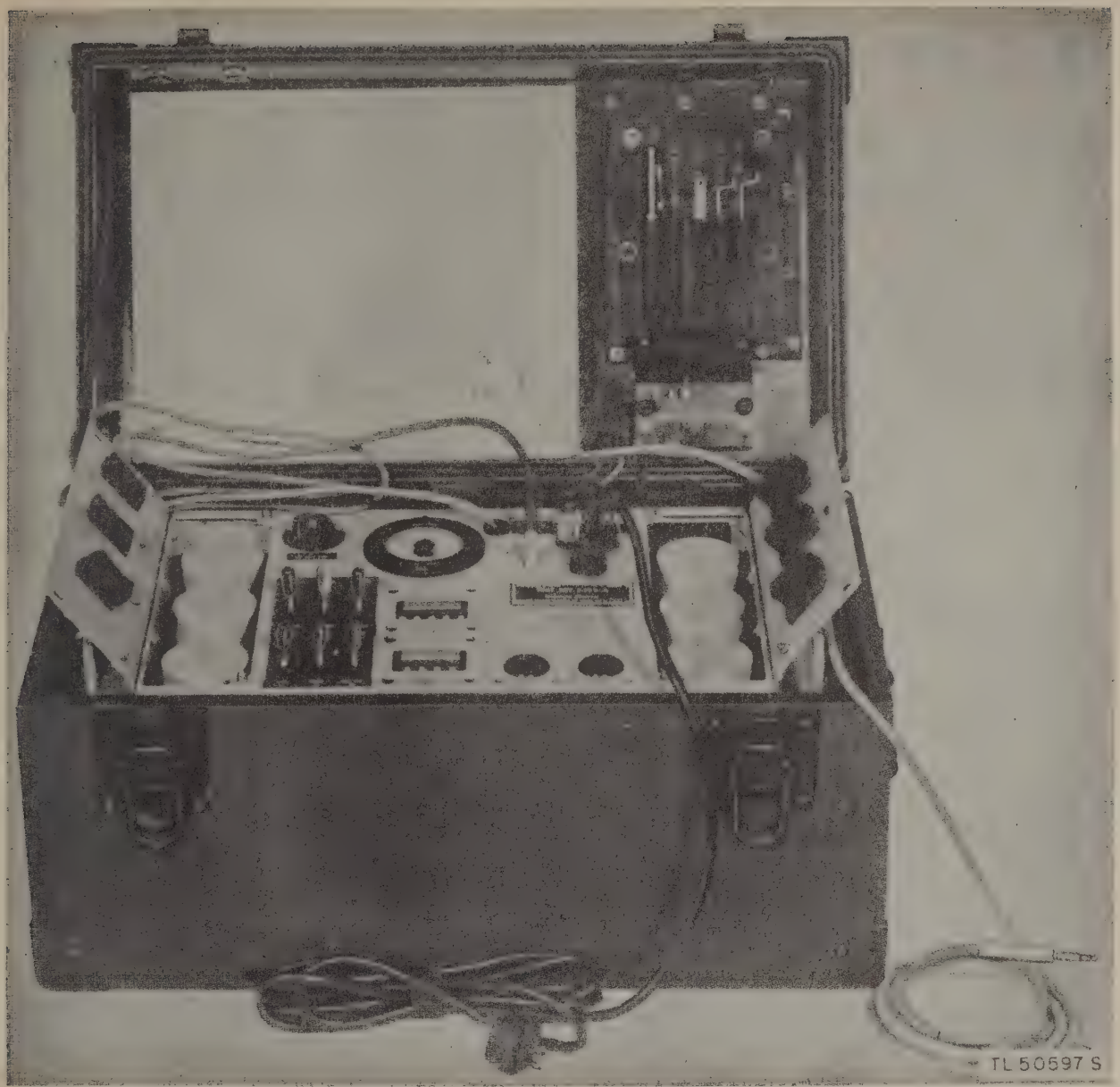


Figure 23. Test Set I-193-A.

range, 0-300 volts; resistance range, 0 to 1,000,000 ohms; internal resistance, 1,000 ohms per volt, both a-c and d-c scales.

b. Test Set I-193-A. This test set is used for testing and adjusting the polar relays used in the repeater. The rectifier power unit in Repeater TG-31 may be used as a source of d-c power for operation of Test Set I-193-A. A cord equipped with a gray-colored shell is supplied with the test set for patching to the battery supply TEST SET jack in Repeater TG-31. Connect the tip (white) conductor of the cord to + BAT, the ring (blue) conductor to — BAT, and the sleeve (red) conductor to GND binding post on the test set. Connect ground to the GND binding post of the repeater and operate the power switches, as covered in paragraph 19, for the source of power available. Adjust the voltage of the repeater as covered in paragraph 19. Any or all of the relays may be removed from the repeater while it is supplying power

for operating the test set. Refer to TM 11-2513 for detailed information on testing and adjusting the polar relays.

62. Trouble-Locating Procedures

The accompanying trouble-locating charts, if properly used, simplify trouble location. Three charts are included.

a. The operator's trouble-locating chart (par. 63) covers sectionalization of trouble in the repeater. This chart lists the various symptoms which may be recognized easily by the operator, and gives the probable location for the existing trouble as well as the recommended correction. The corrections listed are those which the operator can make and which do not require removing the repeater from the carrying case.

b. The repairman's trouble-locating chart (par. 65) covers troubles which the operator may be able to localize, but the correction of which requires removing the repeater from the carrying case.

c. The third chart (par. 66) consists of normal voltage and resistance measurements of the circuit components. As abnormal resistance and voltage measurements are an indication of trouble at the particular point, this chart will be of assistance to the repairman in locating trouble.

63. Operator's Trouble-Locating Chart

Symptoms	Probable trouble	Corrections
No d-c output voltage when operating on 115- or 230-volt alternating current.	115/230V AC–12V STORAGE BAT. switch on 12V STORAGE BAT.	Operate switch to 115/230V AC position.
	Fuse A, B, or D blown	Replace any blown fuses.
	Failure of power supply	Check power supply.
	Open lead in power cord	Repair power cord.
No d-c output voltage when operating on 12-volt storage battery.	115/230V AC–12V STORAGE BAT switch on 115/230V AC position.	Operate switch to 12V STORAGE BAT position.
	Fuse A or C blown	Replace blown fuse.
	Vibrator may not start	Tap vibrator. Replace if it does not start.
	Vibrator contacts may be short-circuited	Replace vibrator.
	Open winding in vibrator	Replace vibrator.
	Open leads to storage battery	Repair leads.
Low d-c output voltage when operating on 115- or 230-volt alternating current.	Low a-c voltage	Check a-c voltage.
	115V AC – 230V AC switch may be on 230V AC position when input is 115-volt alternating current.	Operate switch to 115V AC position.
Low d-c output voltage when operating on 12-volt storage battery.	Storage battery voltage is low	Replace or recharge storage battery.
	Vibrator contacts burned or pitted	Replace vibrator.
High d-c output voltage when operating on alternating current.	High a-c voltage	Check a-c voltage.
Erratic d-c output voltage when operating on alternating current.	Loose connection in power plug	Repair power cord.

Symptoms	Probable trouble	Corrections
Erratic d-c output voltage when operating on storage battery.	Loose connections in leads to storage battery.	Tighten connections.
	Vibrator contacts burned or pitted.....	Replace vibrator.
Errors on printed copy at teletypewriter on incoming signals.	Relay A, B, or R out of adjustment.....	Replace defective relay.
Errors on printed copy at teletypewriter when sending locally.	Relay S or R out of adjustment.....	Replace defective relay.
No tone in headset when telegraph key is held down (manual telegraph operation).	ADJ TONE knob in extreme clockwise position.	Turn ADJ TONE knob to its extreme counterclockwise position, and then turn it slowly in the clockwise direction until proper tone is obtained.
	Neon lamp (TONE) is burned out.....	Replace neon lamp.

64. Trouble Location with Repeater out of Service

a. If the repeater cannot be made to work properly by the procedure covered in the operator's trouble-locating chart (par. 63), it will be necessary to remove the repeater from service and test for trouble.

b. In locating an unknown trouble the use of a terminal Repeater TG-30 in combination with intermediate Repeater TG-31 will be useful. The two repeaters may be set up with a dummy line consisting of a resistance of 500 ohms. This dummy line will not provide a way for making transmission measurements because it is not representative of a real line as regards electrical characteristics. The dummy line, however, permits communication between the two repeaters using teletypewriters or manual telegraph sets.

Caution: Do not touch terminals with hands as high voltages are present. Do not allow one test pick to touch two metal parts at the same time because dangerous short circuits may occur. The procedures described in point-to-point voltage and resistance measurement chart are intended as a guide for making point-to-point voltage measurements. Typical test values are not absolute and are provided only as a basis of comparison with the voltage or resistance measurement found when testing the individual items of apparatus. When making point-to-point voltage test in a series circuit, consideration must be given to a possible ± 15 percent allowable variation in resistance connected in the circuit with the apparatus under test.

65. Repairman's Trouble-Locating Chart

Symptoms	Probable trouble	Corrections
No d-c output voltage when operating on 115- or 230-volt alternating current.	Poor contact in 115V AC–230V AC switch or 115/230V AC–12V STORAGE BAT switch.	Repair or replace defective switch.
	ADJUST VOLTS switches may not be making contact.	Repair or replace defective switch.
	Shorted capacitor A, B1, or B2 in rectifier unit.	Replace defective capacitors.
	Open winding in transformer T1 or retardation coil L1.	Replace transformer or retardation coil.
	Open rectifier wiring.....	Check and repair wiring.

Symptoms	Probable trouble	Corrections
No d-c output voltage when operating on 12-volt storage battery.	Poor contact in 115V AC–230V AC switch or 115/230V AC–12V STORAGE BAT switch.	Repair or replace defective switch.
	ADJUST VOLTS switches may not be making contact.	Repair or replace defective switch.
	Short-circuited capacitor A, C, E, B1, or B2 in rectifier unit.	Replace any defective capacitor.
	Open winding in transformer T1 or retardation coil L1 or L2.	Replace transformer or defective retardation coil.
Low d-c output voltage when operating on 115- or 230-volt alternating current or 12-volt storage battery.	Varistors H1 and H2 are defective.....	Replace varistors.
Erratic d-c output voltage when operating on alternating current.	Loose connection in rectifier wiring.....	Repair wiring.
	Electrolytic capacitor B1 or B2 may be defective (par. 73).	Replace defective capacitor.
Erratic d-c output voltage when operating on storage battery.	Loose connection in rectifier wiring.....	Repair wiring.
Errors on teletypewriter printed copy..	Poor jack or plug contacts on local teletypewriter cords.	Repair or replace jacks or plugs.

66. Point-to-Point Voltage and Resistance Measurement Chart

Purpose of test	Preparation	Part tested and readings
1. To check resistance of windings of polar relay (fig. 24).	Remove relay from repeater. Viewing relay from the terminal pin side, as shown in figure 5, the terminal just to the right of top center will be terminal 1. The terminals are numbered consecutively from this point in a clockwise direction.	*Windings* — *Resistance value* 3–6 — 90 ±9 ohms 2–7 — 1,450 ±145 ohms 8–9 — 1,450 ±145 ohms Check all terminals for ground-to-relay framework. No terminals should be grounded and each should indicate infinite resistance to the framework.
2. To check voltage drops in rectifier power unit when operating on 115-volt a-c input with teletypewriter connected to jacks S and R and to PRINTER POWER receptacle (fig. 32).	Connect ground to GND binding post. To each LINE A and LINE B binding post, connect an adjustable resistance box in series with a milliammeter (Line Unit BE–77–A may be used) to a source of about 115 volts negative with the positive side grounded. Adjust line current to 18 milliamperes and voltage of Repeater TG–31 to 115 volts.	*Voltage drop across* — *Voltage measurements* Transformer T2. Terminal 1 to terminal 3. — 115 volts alternating current. Transformer T1. Terminal 1 to terminal 4. — 115 volts alternating current. Transformer T1. Terminal 8 to terminal 18. — 147 volts alternating current A-c input to varistors H1, H2. Center terminal H1 to center terminal H2. — 103 volts alternating current.

Purpose of test	Preparation	Part tested and readings	
		D-c output of varistors H1, H2. Terminal 1 (+) to terminal 3 (−).	115 volts direct current.
		Coil L1. Terminal 1 (+) of varistors H1 or H2 to positive 115-volt d-c terminal.	0.15 volts direct current.
		115-volt d-c (+) and (−) terminals.	115 volts direct current.
3. To check voltage drop in rectifier unit when operating on 12-volt storage battery (voltage 11.5 at + and − 12V STORAGE BAT terminals).	Repeater arranged as in item 2. Except teletypewriter not connected. Adjust line current to 18 milliamperes and voltage to 127 volts.	A-c input to varistors H1, H2. Center terminal H1 to center terminal H2.	104 volts alternating current.
		D-c output of varistors H1, H2. Terminal 1 (+) to terminal 3 (−).	95 volts direct current.*
		Voltage applied to vibrator G. Positive (+) 12V STORAGE BAT terminal to terminal 1 of coil L2.	11.45 volts direct current.
		Coil L2. Terminal 1 to terminal 2 of coil L2.	0.05 volts direct current.
		115-volt d-c + and − terminals	127 volts direct current.
4. To check voltage drop across retardation coils, varistors, and resistors in repeater circuit when in a marking condition.	Repeater arranged as in item 2.....	*Voltage drop across*	*D-c voltage measurement*
		Retardation Coil A.	0.8 volt
		Retardation Coil B.	0.8 volt
		Resistor J.	105 volts
		Resistor H.	110 volts
		Resistor N.	51 volts
		Resistor P.	51 volts
5. To check voltage drop across retardation coils, resistors, and varistors in repeater circuit.	Repeater arranged as in item 2. Send repeat space characters from teletypewriter keyboard.	Retardation Coil C.	½ volt average.
		Retardation Coil D.	½ volt average.
		Varistor A.	14 volts average.
		Varistor B.	14 volts average.
		Resistor A (400-ohm section).	5.5 volts
		Resistor B (400-ohm section).	5.5 volts

* Though the direct current from the storage battery is converted to an approximate equivalent of a 60-cycle a-c supply, the waveform produced by the vibrator is irregular and is not a true 60-cycle sine wave. As a result, the rectifier d-c output voltage will be lower when a 12-volt storage battery is used for power supply than when the power supply is 60-cycle alternating current.

Purpose of test	Preparation	Part tested and readings
6. To check voltage drop of resistors...	Repeater arranged as in item 2 except that a dummy wooden plug is inserted in jack S instead of teletypewriter send cord, and current in LINE A and LINE B is readjusted to 45 milliamperes. Voltage under this condition will be about 114 volts.	Resistor K. 92 volts Resistor L. 92 volts Resistor G (each 3,000-ohm section). 12 volts Resistor A (50-ohm section). 2.3 volts Resistor B (50-ohm section). 2.3 volts
7. To check capacitor A and 200-ohm section of resistor S connected to capacitor A.	Repeater is arranged as in item 6. Connect voltmeter from midpoint of varistor A to ground. Remove relay A.	Meter should read 125 volts.
	Remove relay B.....	Meter reading should fall gradually to zero.
8. To check capacitor B and 200-ohm section of resistor S connected to capacitor B.	Repeater is arranged as in item 6. Connect voltmeter from midpoint of varistor B to ground. Remove relay B.	Meter should read 125 volts.
	Remove relay A.....	Meter reading should fall gradually to zero.
9. To check spark-killer resistors and capacitors.	Use voltohmmeter as an ohmmeter. Remove all relays and disconnect power cord.	Resistors C, D, and E should show a resistance of 3,200 ohms total (1,600 ohms each side of center tap). Resistor M should measure 1,600 ohms. Capacitors C, D, E, F, G, H, and J should show infinite resistance terminal-to-terminal and both terminals-to-ground.

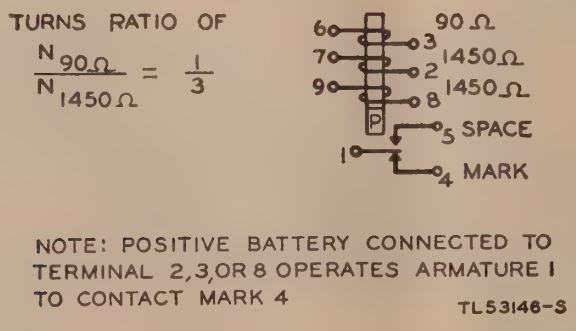


Figure 24. Winding and terminal arrangements of polar relay.

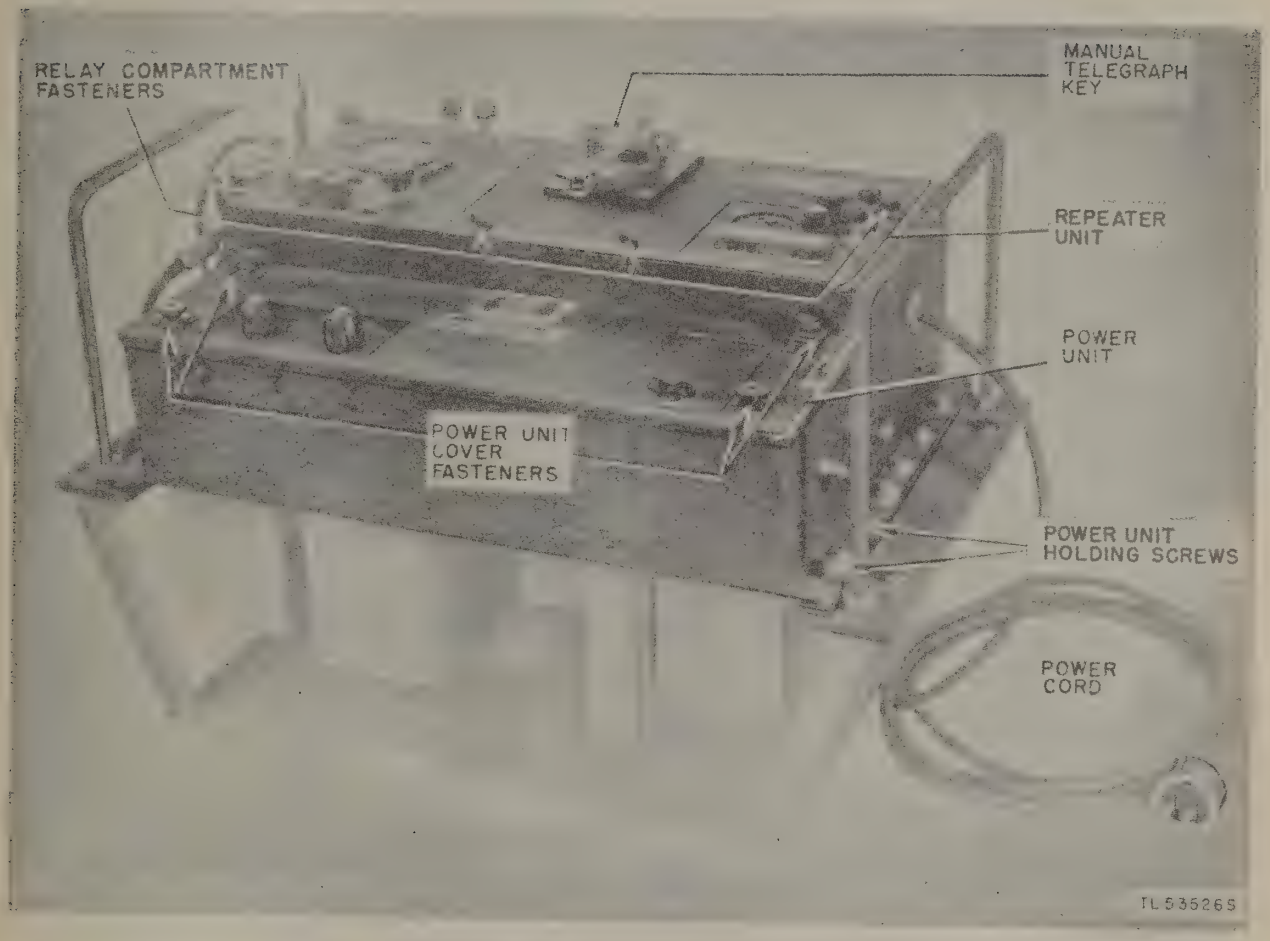


Figure 25. Repeater TG-31 (Intermediate, Telegraph), removed from carrying case, front view.

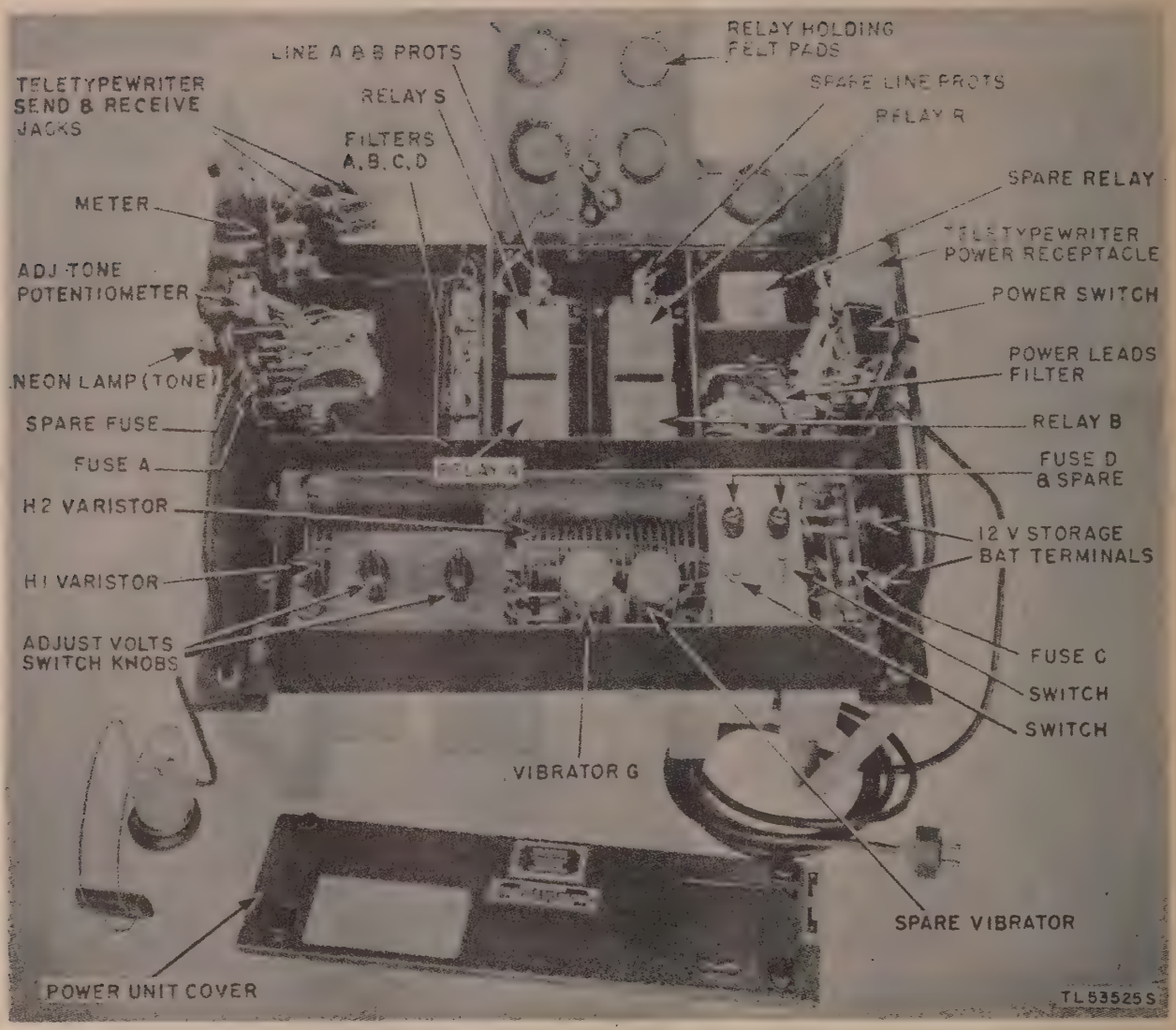


Figure 26. Repeater TG-31 (Intermediate, Telegraph), top panels open.

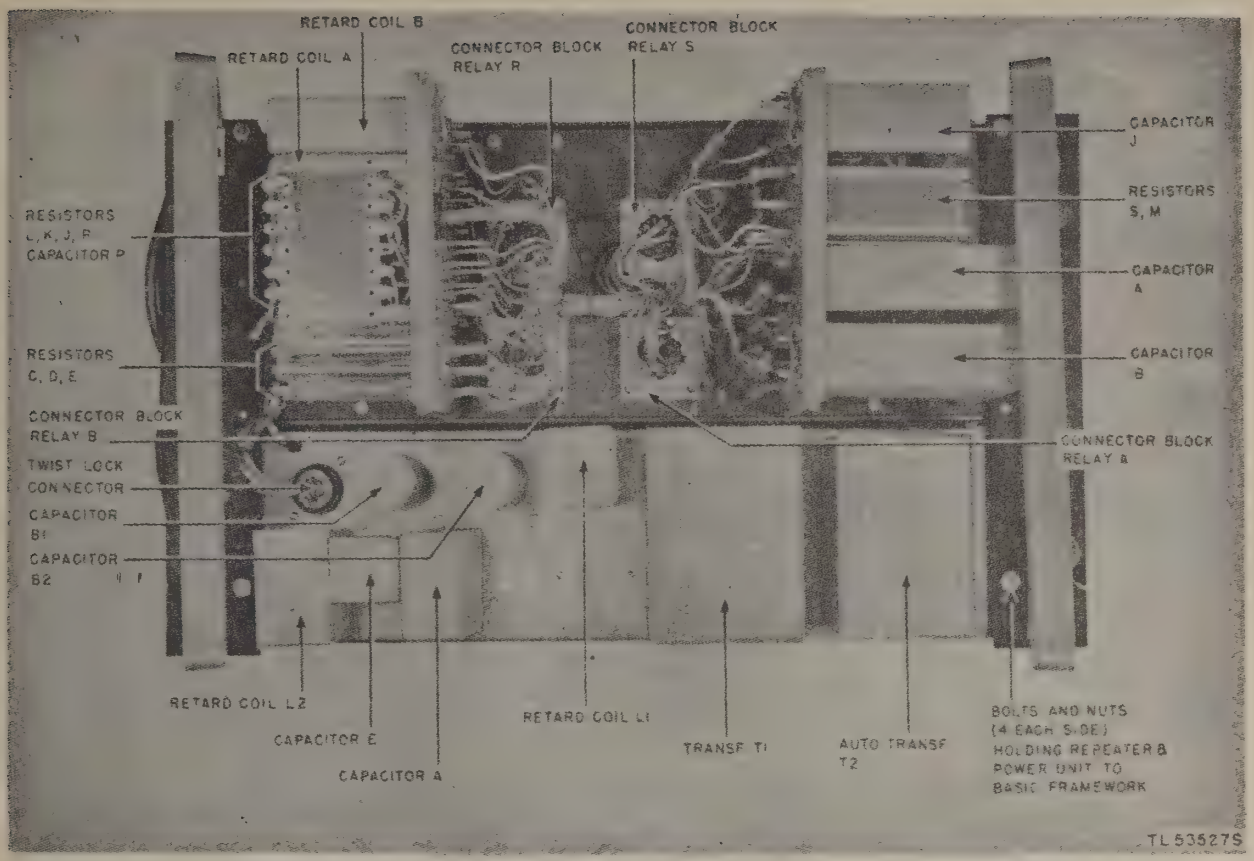


Figure 27. Repeater TG-31 (Intermediate, Telegraph), rear view.

Section XV. REPAIRS

67. Disassembly for Repair

a. Removing Unit from Carrying Case. Disconnect all wires and cords. Loosen the four large roundhead assembly screws designated in figure 4. These screws hold the basic framework of the equipment to the carrying-case brackets. Lift the unit from the carrying case, using the side handles, and place the unit on a bench, or other suitable support for testing.

b. Removing Rectifiers Power Unit from Repeater Unit. After removing the unit from the carrying case, disconnect the twist-lock plug connection (fig. 27) at the left-hand side of the power unit and disconnect the wires connected to the + and — 115-volt d-c terminals on the terminal strip located at the right-hand side of the power unit. On each side bracket remove the roundhead holding screws which mount the power unit to the framework (fig. 25). The power unit may now be removed from the framework. When replacing the positive and negative 115-volt d-c leads, refer to the color codes shown in the wiring of the circuits (fig. 33).

68. Replacement of Vibrator

Vibrator G is a sealed unit which cannot be serviced or adjusted in the field. Should it fail to function properly, as indicated by excessive noise or by a low-voltage d-c output which cannot be compensated for by the voltage-adjusting switches, it should be replaced. A spare vibrator is furnished in the power unit (fig. 26).

Note. Occasionally a vibrator will fail to start because of dirty or oxidized contact points. If the vibrator will not start, remove the power unit cover and tap the vibrator lightly. In many cases the vibrator will start to function. Then operate the vibrator for about ½ hour to recondition the contact points.

69. Replacement of Fuses

To replace a fuse, unscrew the fuse cap and extract the fuse with the cap. Insert the new fuse in the

fuse holder and replace the cap. A spare fuse and fuse holder are provided on the panel for each type of fuse. The location of the fuses referred to in table IV are shown in figures 4 and 26.

Table IV. Fuse chart.

Equipment designation and type	Location	Function	Circuit designation
½ AMP...	Adjacent to HEADSET jack.	Fuses positive supply to repeater circuit.	A
5 AMP....	Adjacent to PRINTER POWER receptacle.	Main power-supply fuse.	B
10 AMP...	Underneath power unit cover near 12-volt storage battery binding posts.	Protection for 12-volt storage battery supply circuit.	C
1 AMP....	Underneath door on right side of power unit cover.	Protection for a-c input circuit.	D

70. Replacement of Lamp in Manual Telegraph Circuit

The neon lamp designated TONE should light when the headset is connected and the telegraph key held down. The lamp is not brilliant, and in sunlight it is advisable to shade the lamp when checking its operation. To replace lamp, unscrew lamp cap and pull out the lamp. Spare lamps are located in the spare lamp and fuse compartment in the cover.

71. Replacement of Other Parts

a. Most of the parts in Repeater TG-31 (Intermediate, Telegraph) may be easily replaced if they are found to be faulty.

b. When replacement of any part requires the disconnection of several wires, mark the wires with tags or other identifying devices to insure proper connection when the new part is installed.

c. When replacing leads, clip them as short as possible for satisfactory connection and avoid using more solder than necessary to make a secure connection. A very slight amount of excess solder dropped accidentally inside the equipment may cause other circuits or circuit elements to be short-circuited. Do not heat the lug or connection more than is absolutely necessary to make a well-soldered connection. Excess heat may damage capacitors, resistors, and wiring. When a wire is connected to a relay socket the connection should be long enough to prevent any pull on the socket. Save time and trouble by making a thorough electrical check of any part that appears to be defective *before* removing it from the equipment.

d. When replacing parts in the equipment, use care in disassembly and reassembly. Use screwdrivers and other tools that fit the job at hand. Secure bolts and screws snugly but do not overtighten them.

72. Installation of Gas Adsorber Units

a. Gas adsorber units are available in quantities of two per vaporproof envelope, complete with two fastening clamps and one instructive photograph, similar to figure 7. This envelope is called a Gas Adsorber Assembly and contains sufficient material for equipping one relay. *Do not open the envelope until ready to use.*

b. To install these units follow the self-explanatory photograph included in the assembly envelope. Place one unit on each side of the relay frame, clip the fastening clamps in place over the frame edges, and replace the relay cover.

c. On new equipment, gas adsorber units are installed on each relay in use and one set of spare gas adsorber assemblies are furnished for each relay. For equipment which does not con- gas adsorber units, the assemblies may be requisitioned from depot stock as Gas Adsorber Assembly, Signal Corps stock No. 6Z60. The assembly consists of two metal wire-cloth bags each containing two grams of charcoal, two fastening clamps, and one instructive photograph. The gas adsorber unit is shown in figure 28.

73. Restoration of Electrolytic Capacitors

Electrolytic capacitors B1 and B2 in the rectifier may lose their film if the equipment is held in storage or if it is operated on a d-c supply for a period of 18 months or longer. Replace these capacitors after 3½ years from date stamped on the case whether or not the equipment is in service. Normal operation on a-c power will maintain the capacitors in the proper operating condition. To

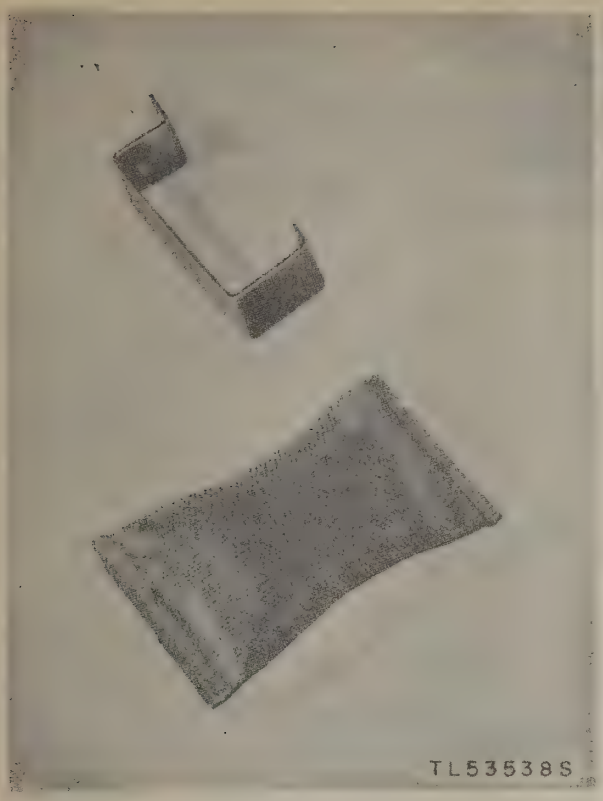


Figure 28. Gas adsorber unit.

restore the film, connect the power cord of the repeater to an a-c supply for at least 30 minutes every 18 months. If an a-c supply is not available, a source of 96 to 120 volts d-c with 110/120-volt lamp (25 to 100 watts) in series may be connected to the positive and negative terminals of the rectifier power unit for at least 30 minutes every 18 months. Connect the positive side of this lamp circuit to the +DC terminal and the negative side to the —DC terminal on the rectifier power unit output terminal block. To make a connection to these terminals, remove the rectifier power unit cover (figs. 26 and 32).

74. Painting and Refinishing

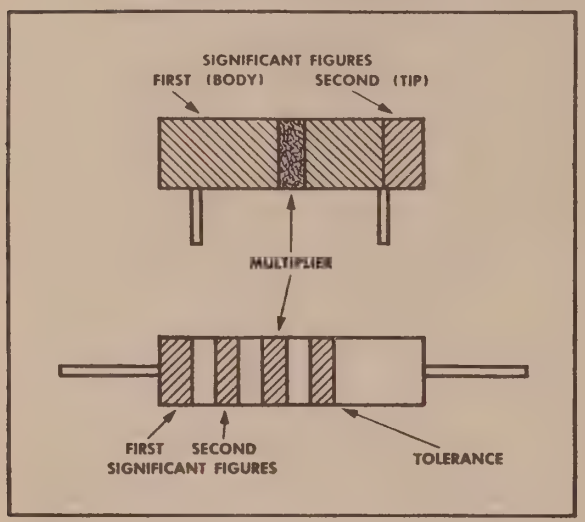
When a touch-up job is necessary, apply paint with a small brush. When numerous scars and scratches warrant complete repainting, remove the repeater from the carrying case and spray paint over the entire case. Remove rust from the hinges and catches by cleaning corroded metal with dry-cleaning solvent (SD). In severe cases it may be necessary to use dry-cleaning solvent (SD) to soften the rust on metal parts, and then use sandpaper to complete the preparation for painting.

Caution: The use of steel wool, although permiting rapid removal of rust, is not recommended. Minute particles of steel wool frequently enter the case and cause harmful internal shorting or grounding of circuits.

Paint used will be authorized and consistent with existing regulations.

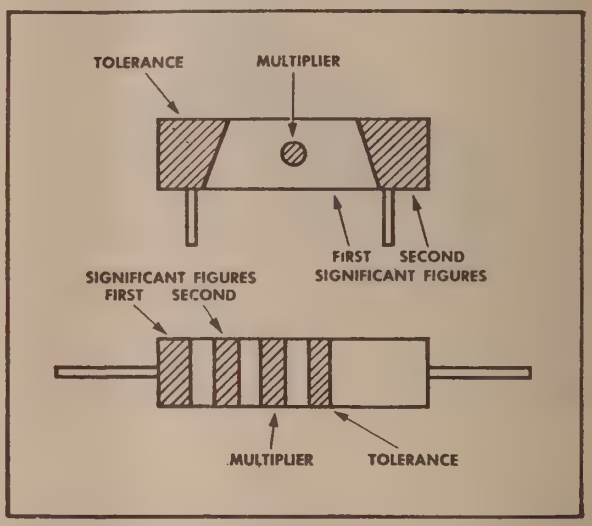
RESISTOR COLOR CODES

RMA COLOR CODE FOR FIXED COMPOSITION RESISTORS



Insulated fixed composition resistors with axial leads are designated by a natural tan background color. Non-insulated fixed composition resistors with axial leads are designated by a black background color.

JAN COLOR CODE FOR FIXED COMPOSITION RESISTORS



Resistors with axial leads are insulated. Resistors with radial leads are uninsulated.

COLOR	SIGNIFICANT FIGURE	MULTIPLIER	TOLERANCE (PERCENT)
BLACK	0	1	
BROWN	1	10	
RED	2	100	
ORANGE	3	1,000	
YELLOW	4	10,000	
GREEN	5	100,000	
BLUE	6	1,000,000	
VIOLET	7	10,000,000*	
GRAY	8	100,000,000*	
WHITE	9	1,000,000,000*	
GOLD		0.1*	5
SILVER		0.01*	10
NO COLOR			20

*JAN ONLY

Example: A 50,000-ohm resistor with a standard tolerance of 20 percent (no color) would be indicated by a green ring (5), a black ring (0), and an orange ring (000)

RMA: Radio Manufacturers Association
JAN: Joint Army-Navy

TL 13418 A

Figure 29. Resistor color codes.

APPENDIX I

LIST OF COMPONENT PARTS OF REPEATER TG-31 (INTERMEDIATE, TELEGRAPH)

Quantity	Component
1.....	Repeater TG–31 (Intermediate, Telegraph).
*1(3).....	Fuse FU–26 (1 amp).
2.....	TM 11–2005.
2(2).....	Block, protector carbon.
2(2).....	Block, protector.
1(4).....	Fuse, ½ amp 250 v.
1(3).....	Fuse, 5 amp 25 v.
1(3).....	Fuse, 10 amp 250 v.
1(3).....	Lamp, neon LF 5122.
4(1).....	Relay: sb, 3 windings.
5(5).....	Gas adsorber assembly.

Note: This list is for general information only. See appropriate publications for information pertaining to requisition of spare parts.

* Quantitites shown in parentheses are running spares.

APPENDIX II

MAINTENANCE PARTS FOR REPEATER SET TC-19

The following information was compiled on 14 June 1945. The appropriate pamphlets of the ASF Signal Supply Catalog for Repeater Set TC-19 are:

Sets of equipment. SIG 6-TE-49.

Organizational spare parts. SIG 7-TC-19.

Higher echelon spare parts. SIG 8-TC-19.

Telegraph repeater, intermediate, fixed plant maintenance list. SIG 10-841.5—Repeater TG-30 and Repeater TG-31.

For the latest index of available catalog pamphlets, see Signal Supply Catalog SIG 1 and 2.

Note. This list covers first and second echelon maintenance parts. No third echelon maintenance parts are authorized for Repeater Set TC-19.

Ref symbol	Signal Corps stock No.	Name
Fig. 1	3Z3330–148	Ground rod.
Fig. 30 (1)	4E926	Block, protector.
Fig. 30 (2)	4E927	Block, protector.
Fig. 30 (3)	3Z2605.8	Fuse.
Fig. 30 (4)	3Z1926	Fuse.
Fig. 30 (5)	3Z2595.6	Fuse.
Fig. 30 (6)	3Z2610.10	Fuse.
Fig. 30 (7)	2Z5888	Lamp, neon.
Fig. 30 (8)	4C9156	Relay.

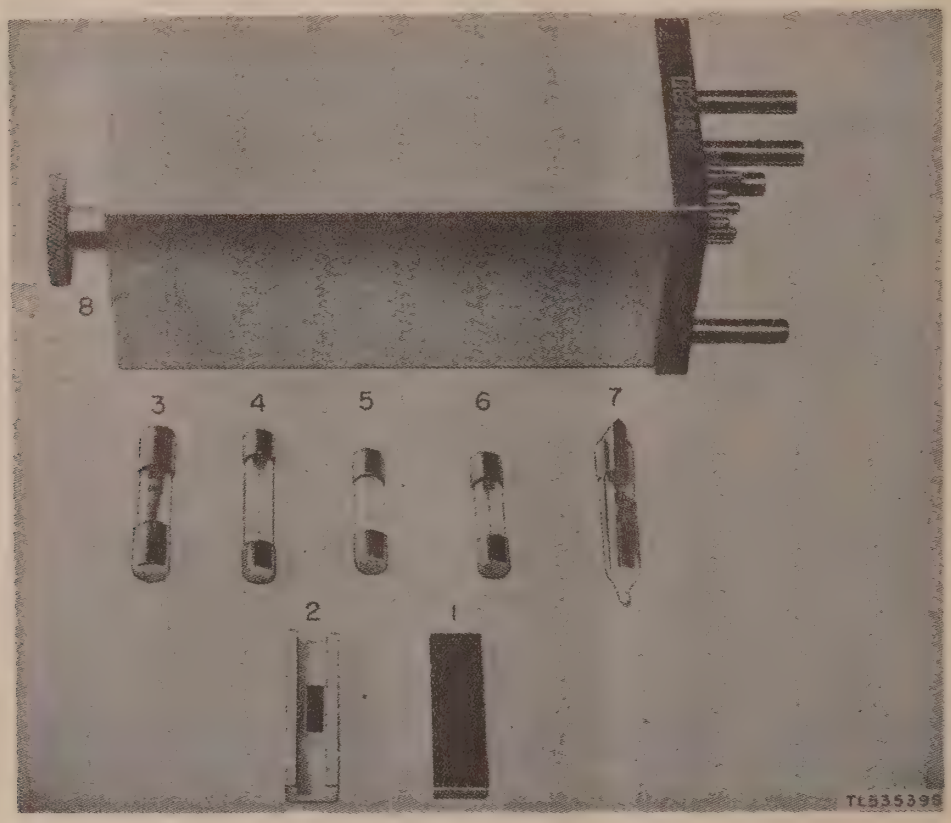


Figure 30. Maintenance parts for Repeater TG-31 (Intermediate, Telegraph).

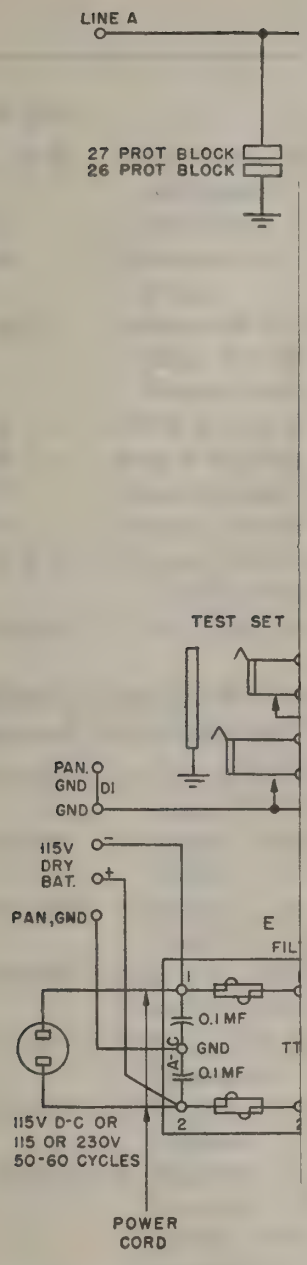

LINE A
27 PROT BLOCK
26 PROT BLOCK
TEST SET
PAN. GND
GND
D1
115V DRY BAT.
PAN, GND
E
FIL
0.1 MF
GND
0.1 MF
A-C
TT
115V D-C OR
115 OR 230V
50-60 CYCLES
POWER CORD

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Fig. 30 (7)	2Z5888	Lamp, neon.
Fig. 30 (8)	4C9156	Relay.

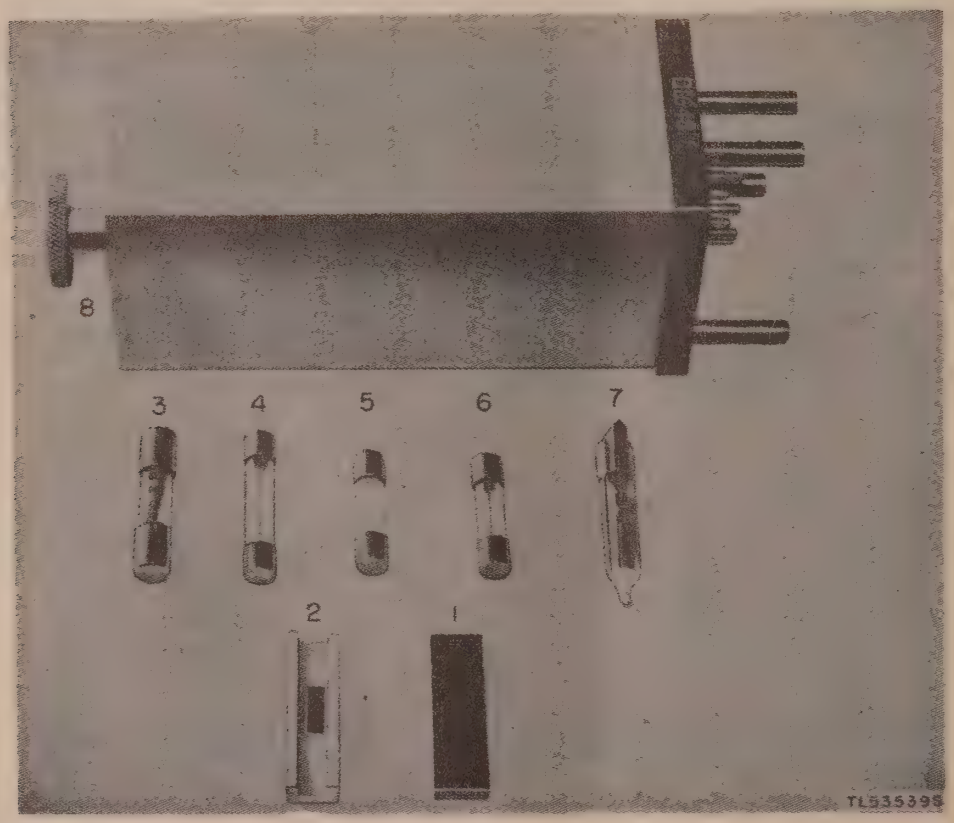

Figure 30. Maintenance parts for Repeater TG-31 (Intermediate, Telegraph).

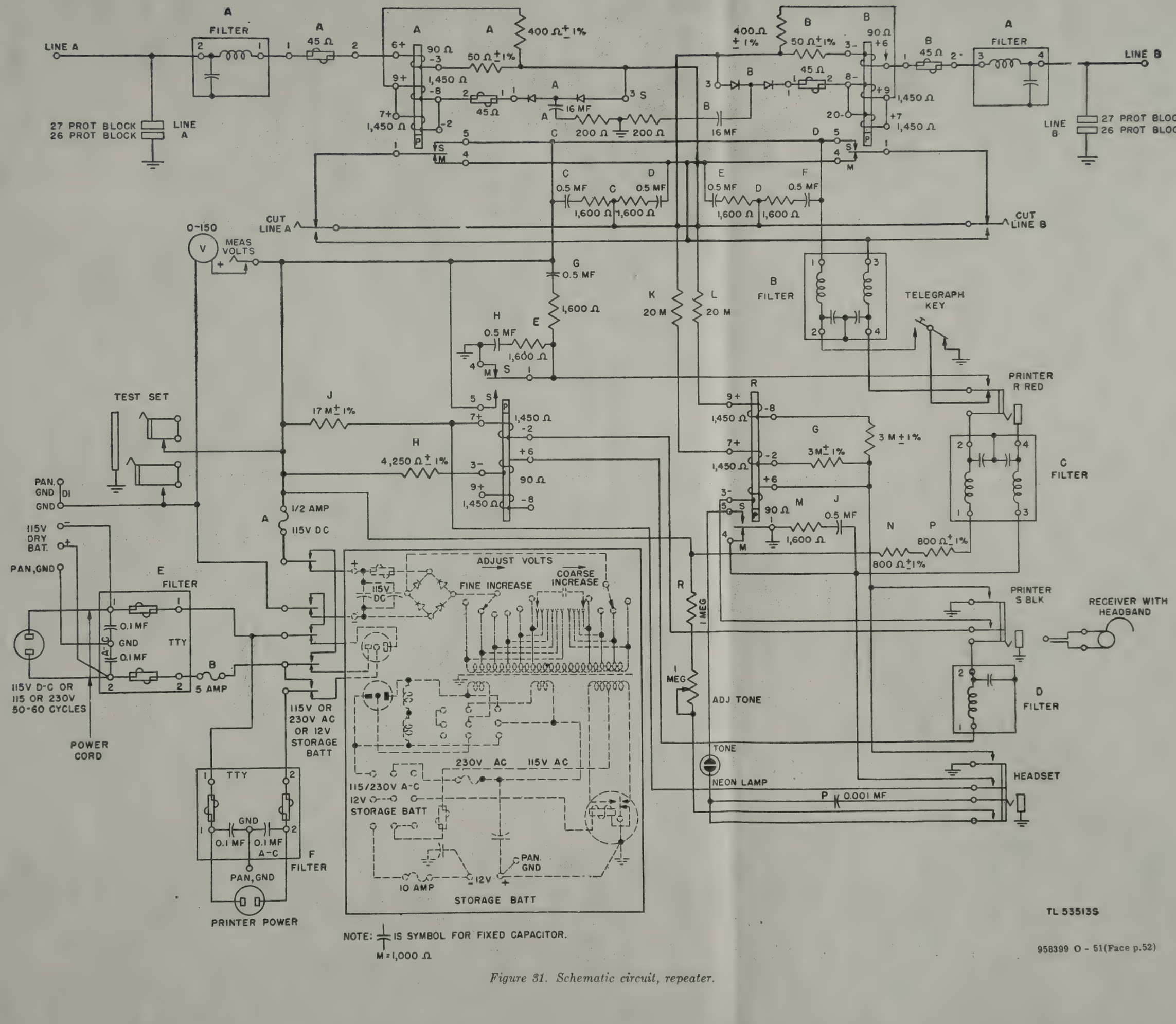

Figure 31. Schematic circuit, repeater.

APPENDIX III

REFERENCES

1. Parts List

SIG 1 & 2.....Introduction and Index to Signal Supply Catalog.
SIG 3 .....List of Items for Troop Issue.
SIG 4-1 .....Allowances of Expendable Supplies.
SIG 4-2 .....Allowances of Expendable Supplies for Schools, Training Centers, and Boards.
SIG 5 .....Stock List of All Items.
SIG 6 .....Sets of Equipment.
SIG 7 .....Organizational Spare Parts.
SIG 8 .....Higher Echelon Spare Parts.
SIG 7 & 8.....Organizational and Higher Echelon Spare Parts.
SIG 10-841.5....Fixed Plant Maintenance List.

2. Technical Manuals of Associated Equipment and Test Equipment

TM 11-352 ....Printer TG-7-A and Teletypewriters TG-7-B and TG-37-B.
TM 11-355 ....Telegraph Terminal CF-2-A (Carrier).
TM 11-355B ..Telegraph Terminal CF-2-B (Carrier).
TM 11-359 ....Line Units BE-77, BE-77-A, and BE-77-B.
TM 11-2004 ..Repeater Set TC-18 (Terminal, Telegraph).
TM 11-2009 ..Telegraph Terminal CF-6 (Carrier).
TM 11-2029 ..Carrier Terminals OA-4/FC and OA-5/FC. (Voice - frequency Carrier Telegraph Packaged Equipment).
TM 11-2034 ..Telegraph Repeater OA-6/FC. (D-c Telegraph Repeater Packaged Equipment).
TM 11-2206 ..Telegraph Terminal Set AN/-TCC-1, Telegraph Terminal TH-1/TCC-1, and Filter F-2/GG.
TM 11-2220 ..Reperforator Transmitters TG-26-A and TG-27-A.
TM 11-2513 ..Test Set I-193-A.
TM 11-2613 ..Voltohmmeter I-166.

3. Shipping Instructions

U. S. Army spec No. 100-14A ....Army-Navy General Specifications for Packaging and Packing for Oversea Shipment.

4. Decontamination

TM 3-220 .....Decontamination.

5. Camouflage

FM 5-20 .....Camouflage, Basic Principles.

6. Other Publications

FM 21-6 .....List and Index of War Department Publications.
FM 21-7 .....List of War Department Films, Film Strips, and Recognition Film. Slides.
FM 21-8 .....Military Training Aids.
FM 21-40 .....Defense Against Chemical Attack.
TB SIG 13.....Moistureproofing and Fungiproofing Signal Corps Equipment.
TB SIG 25.....Preventive Maintenance of Power Cords.
TB SIG 66.....Winter Maintenance of Signal Equipment.
TB SIG 69.....Lubrication of Ground Signal Equipment.
TB SIG 72.....Tropical Maintenance of Ground Signal Equipment.
TB SIG 75.....Desert Maintenance of Ground Signal Equipment.
TM 1-455 .....Electrical Fundamentals.
TM 11-462 .....Signal Corps Reference Data.
TM 11-755 .....Grounds, Grounding Procedures, and Protective Devices for Wire Communication Equipment.
TM 37-250 .....Basic Maintenance Manual.

7. Forms

WD AGO .....Form 468 Unsatisfactory Equipment Report.
AAF .....Form 54 Unsatisfactory Report.

8. Abbreviations

assem .....assembly.
BAT .....battery.
BLK .....black.
cap. .....capacitor.
conn .....connector.
dx .....duplex.
fil .....filter.
freq .....frequency.
gen .....generator.
GND .....ground.
lmp .....lamp.
ma .....milliampere(s).
MEAS .....measure.
meg .....megohm(s).
mf .....microfarad(s).
mtg .....mounting.
opm .....operations per minute.
pan. .....panel.
pot. .....potentiometer.
prot .....protector.
rcv, R. .....receive.
ry .....relay.
recp .....receptacle.
rect .....rectifier.
res .....resistor.
ret, retard.....retardation.
S .....send.
sb .....switchboard.
spec .....specification.
sw .....switch.
term. .....terminal.
term. st .....terminal strip.
TPDT .....triple pole double throw.
transf .....transformer.
v .....volt(s).
vt .....vacuum tube.

9. Glossary

The following glossary contains information in explanation of technical terms used in this manual:

Battery. The term battery normally is used when referring to a group of dry cells or storage cells. In telegraph communication it is common usage to refer to any d-c source used in production of telegraph signals as battery. Consequently this manual applies the term to the direct current supplied by the rectifier.

Duplex system. A telegraph system which affords simultaneous independent operation in opposite directions over the same channel.

Full-duplex operation. Full-duplex operation of a telegraph system is simultaneous operation in both directions.

Half-duplex operation. Half-duplex operation of a telegraph system is operation of a duplex system arranged to permit operation in either direction at a time but not in both directions simultaneously.

Mark. In neutral operation, the closed circuit signal is referred to as a mark, and the open circuit signal is known as a space. In other than neutral operation, the term mark is applied to the circuit condition which will produce the same result in the terminal equipment that a mark signal produces in neutral operation. Similarly, the term space is applied to the circuit condition which will produce the same result in the terminal equipment that a space signal produces in neutral operation.

Neutral operation. Marking signals are formed by current pulses of one polarity, either positive or negative, and spacing signals are formed by reducing the current to zero or nearly zero.

Neutral relay. A relay which operates in exactly the same way, regardless of the direction in which current flows through its windings.

Polar operation. A type of telegraph transmission in which marking signals are formed by current pulses of one polarity and spacing signals by current pulses of equal magnitude but of opposite polarity.

Polarential operation. A type of telegraph transmission in which signals are sent in one direction by reversing polarity of current and in the other by varying the magnitude of the current.

Polar relay. A relay, the armature of which is pulled to one contact when current flows in one direction through its windings, and to the other contact when current is reversed in direction.

Space. See mark.

Varistor. A dry-disk rectifier such as a selenium or copper-oxide rectifier.

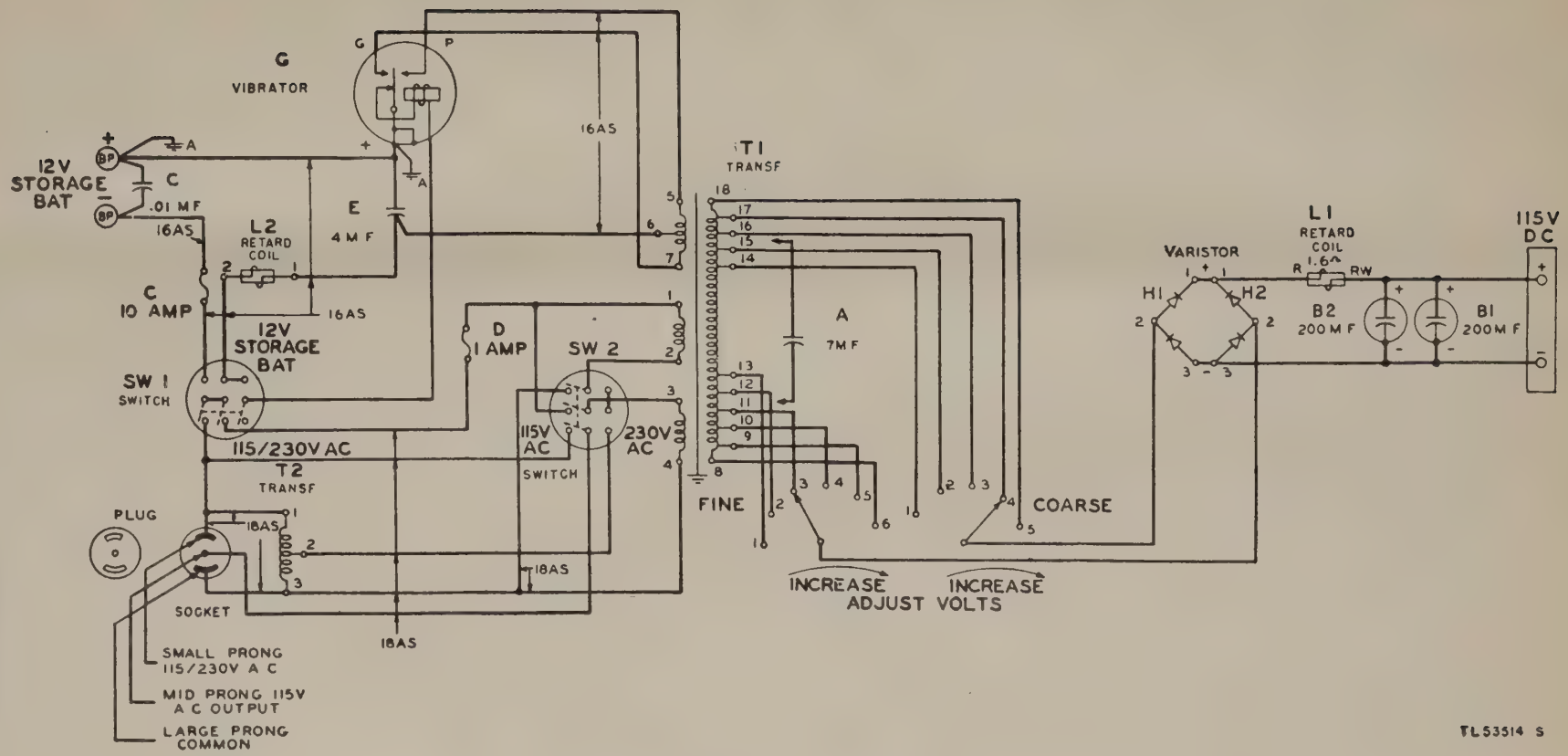

Figure 32. Schematic circuit, rectifier power unit.

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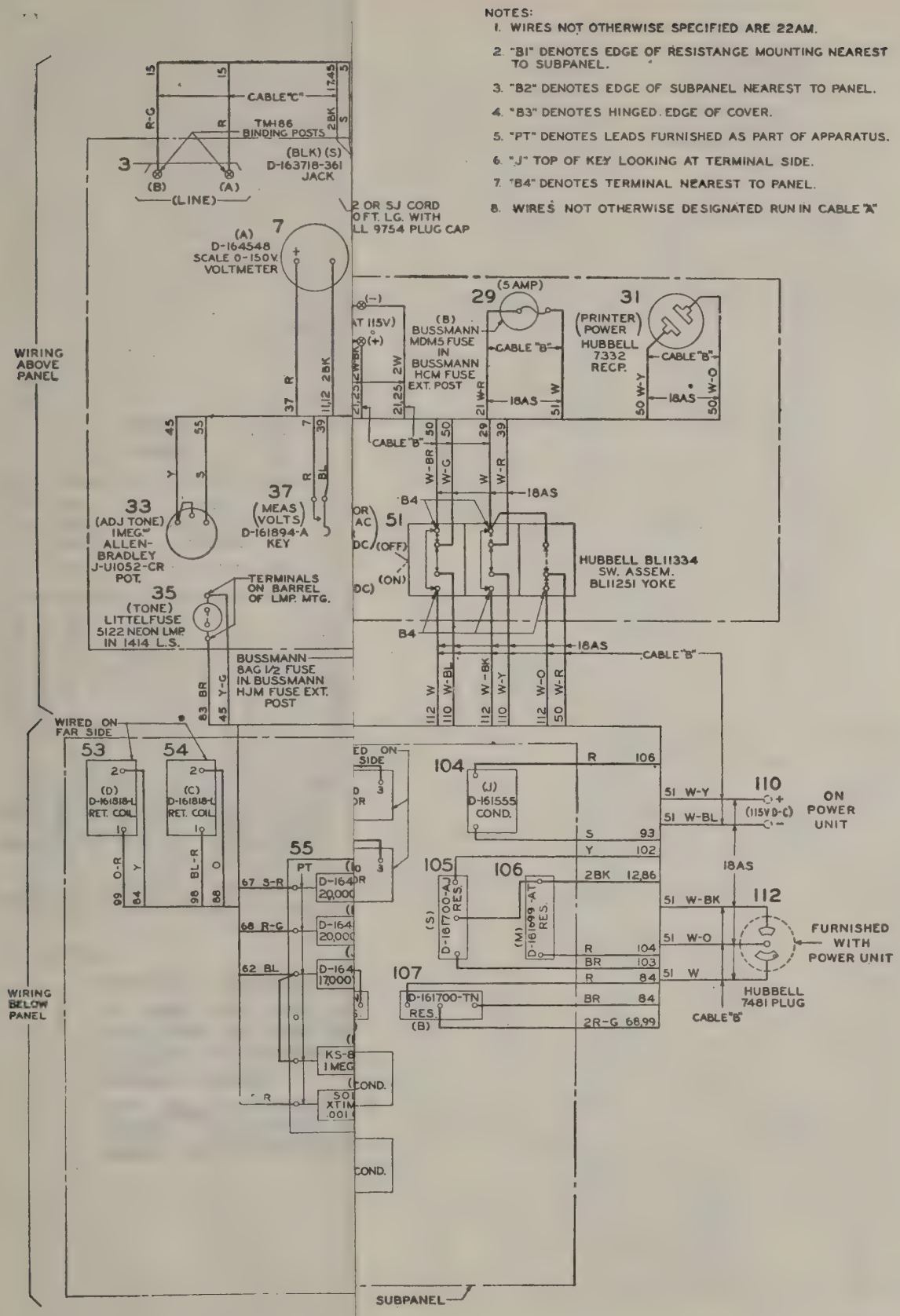
NOTES:
1. WIRES NOT OTHERWISE SPECIFIED ARE 22AM.
2. "B1" DENOTES EDGE OF RESISTANCE MOUNTING NEAREST TO SUBPANEL.
3. "B2" DENOTES EDGE OF SUBPANEL NEAREST TO PANEL.
4. "B3" DENOTES HINGED EDGE OF COVER.
5. "PT" DENOTES LEADS FURNISHED AS PART OF APPARATUS.
6. "J" TOP OF KEY LOOKING AT TERMINAL SIDE.
7. "B4" DENOTES TERMINAL NEAREST TO PANEL.
8. WIRES NOT OTHERWISE DESIGNATED RUN IN CABLE "A"
WIRING ABOVE PANEL
WIRING BELOW PANEL
CABLE "C"
TM-186 BINDING POSTS
(BLK) (S) D-163718-361 JACK
(LINE)
7 (A) D-164548 SCALE 0-150V VOLTMETER
29 (5 AMP)
(B) BUSSMANN MDM5 FUSE IN BUSSMANN HCM FUSE EXT. POST
31 (PRINTER) POWER HUBBELL 7332 RECP.
CABLE "B"
18AS
33 (ADJ TONE) 1MEG ALLEN-BRADLEY J-U1052-CR POT.
37 (MEAS VOLTS) D-161894-A KEY
35 (TONE) LITTELFUSE 5122 NEON LMP. IN 1414 L.S.
TERMINALS ON BARREL OF LMP. MTG.
51 (OFF) (ON)
HUBBELL BL11334 SW. ASSEM. BL11251 YOKE
B4
BUSSMANN 8AG 1/2 FUSE IN BUSSMANN HJM FUSE EXT. POST
WIRED ON FAR SIDE
53 (D) D-161818-L RET. COIL
54 (C) D-161818-L RET. COIL
55 PT
104 (J) D-161555 COND.
105 (S) D-161700-AJ RES.
106 (M) D-161699-AT RES.
107 D-161700-TN RES. (B)
110 (115VD-C) ON POWER UNIT
112 HUBBELL 7481 PLUG
FURNISHED WITH POWER UNIT
CABLE "B"
SUBPANEL

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NOTES:
1. WIRES NOT OTHERWISE SPECIFIED ARE 22AM.
2. "B1" DENOTES EDGE OF RESISTANCE MOUNTING NEAREST TO SUBPANEL.
3. "B2" DENOTES EDGE OF SUBPANEL NEAREST TO PANEL.
4. "B3" DENOTES HINGED EDGE OF COVER.
5. "PT" DENOTES LEADS FURNISHED AS PART OF APPARATUS.
6. "J" TOP OF KEY LOOKING AT TERMINAL SIDE.
7. "B4" DENOTES TERMINAL NEAREST TO PANEL.
8. WIRES NOT OTHERWISE DESIGNATED RUN IN CABLE "A"

Figure 33. Wiring diagram, repeater circuit.

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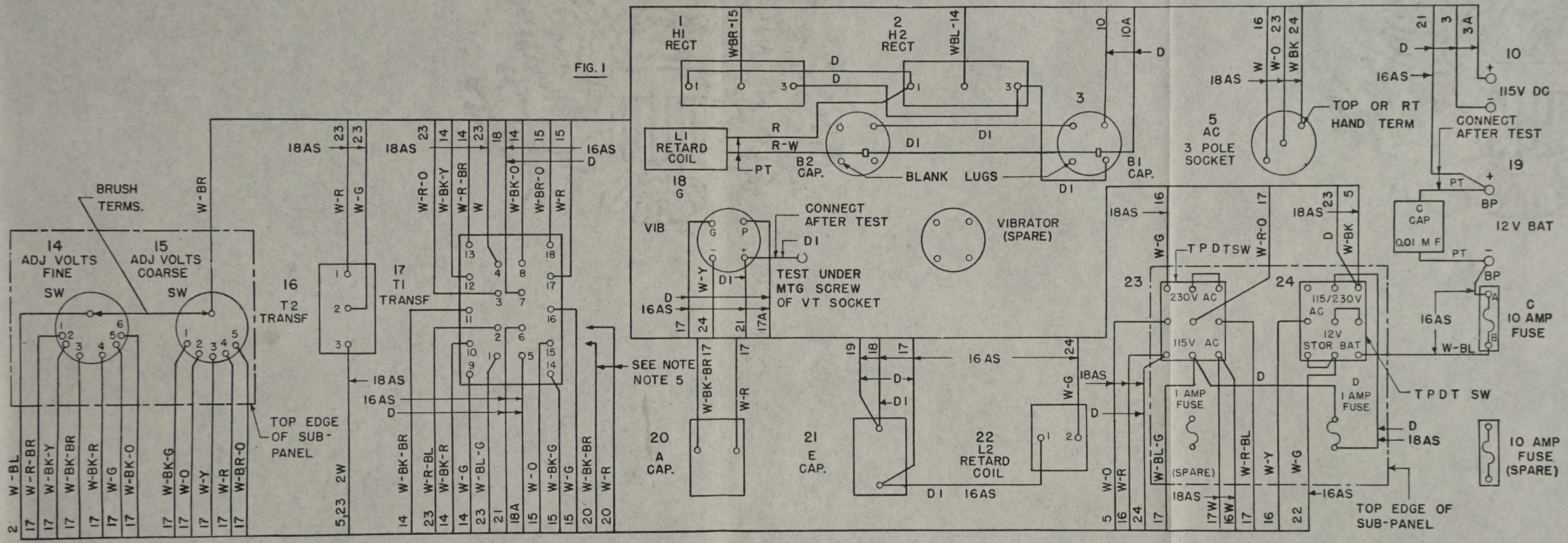
FIG. 1



NOTES:

1. WIRES NOT OTHERWISE SPECIFIED ARE 20AS STRANDED.
2. "D" WIRES ARE WHITE AND ARE NOT SEWED IN THE CABLE FORM BUT RUN PERPENDICULAR AND PARALLEL TO EDGES OF MOUNTING UNIT IN THE SHORTEST POSSIBLE MANNER.
3. "D1" WIRES ARE WHITE AND ARE RUN DIRECTLY FROM TERMINAL TO TERMINAL IN THE SHORTEST POSSIBLE MANNER AND INDEPENDENT OF ALL OTHER LEADS.
4. "PT" LEADS ARE FURNISHED AS PART OF APPARATUS.
5. CONNECTED TO TERMINALS OF T1 TRANSFORMER IN ACCORDANCE WITH SHOP TEST.

Figure 34. Wiring diagram, rectifier power unit.

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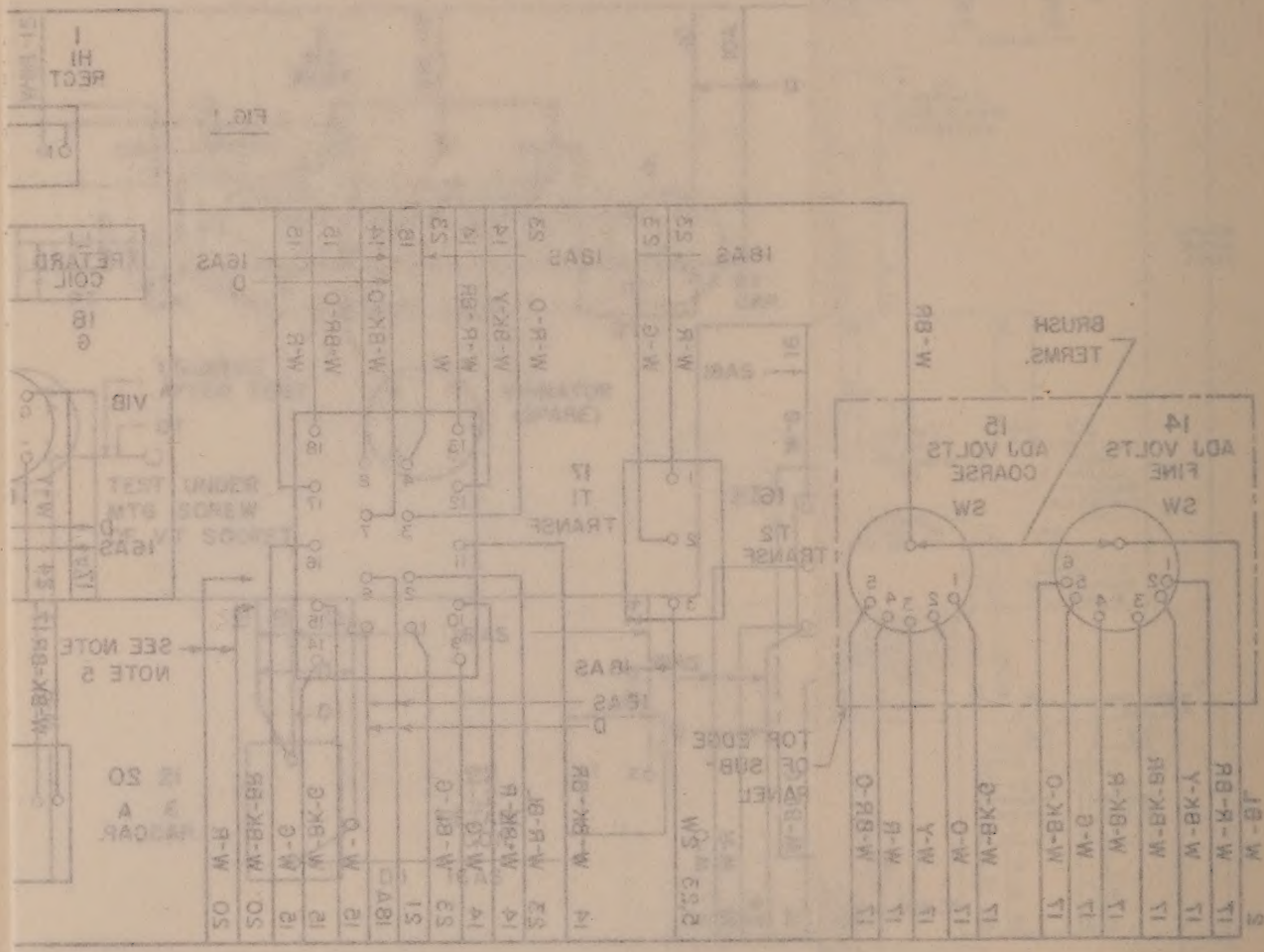

NOTES:

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